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AN ECOLOGICAL STUDY OF A PIECE OF KARROO-LIKE VEGETATION NEAR BLOEMFONTEIN.

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SECTION I.

Introduction.

Bloemfontein lies within the vegetation region characterised by vast, undulating, bunch-grass plains, termed by Bews (1918) the Eastern Grassveld, in which the " rooigras " (*Themeda triandra*) is dominant. It is of interest then to find in this region a small area (approximately 18 square miles) showing marked affinities with the Karroo. Bews (1925) makes mention of similar areas on the very dry valley-slopes of the Tugela, and Lower Mooi rivers in Natal, but as far as can be ascertained the area under discussion is the most northerly outlier of the Karroid type of vegetation.

The terms " bult " and " koppie " are used in this paper in definite contra-distinction. By " bult " is meant a large, mound-like elevation rounded off by gently inclined sides ; the " koppie " is usually higher, with steep sides, and rises sharply from the surrounding levels. The term " bush " is used to denote close or semi-close stands of trees, and by " scrub " is meant vegetation characterised by scattered, stunted trees and shrubs.

Of the nine associations (plant communities) described, five have been named after the dominant species which characterise them, and four after the situations which they inhabit.

For the benefit of those who are not familiar with the botanical names of the plants, the common names of these, where known, will be found together with the botanical names in Section III.

Most of the ecological work in this report was done between December, 1933, and July, 1935.

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GENERAL DESCRIPTION OF SITE.

The region investigated (referred to as the Area) is approximately 18 square miles in extent, and is situated immediately to the north of the townlands of Bloemfontein. It is bounded practically on all sides, as seen in Map 1, by grassveld, and has the general appearance of an island of short, open scrub raised in a sea of gently undulating grass, the continuity of which is broken by the protrusion, at varying intervals, of flat-topped koppies.

The Area is built of koppies and bults separated by winding valleys and gullies (Plate 6A) through which wander dry spruits and sloots. The soil is, on the whole, extremely shallow, and on all sides exposed rock outcrops meet the eye. The site is clothed mainly by short open scrub, in which are scattered small areas of bush and grassland. The level of the Area fluctuates between 4,400 and 4,800 feet altitude. The Area presents an isolated type of vegetation and possesses a number of distinct plant communities.

METHODS.

A reconnaissance of the Area was made, and its boundaries and plant communities noted.

A map of the Area was made showing the distribution of the various associations. The map is based on the Ordnance Survey, enlarged approximately seven times, linear measurement.

Line and belt transects were made through portions of the various plant communities.

Observational records were employed in tracing the early succession.

Photographs were taken to illustrate observations and charts.

Instrumental records were made of various factors operating in the Area. (These records are indicative, rather than absolute, as the cost of the instruments necessary for complete records placed them out of reach.)

Mechanical and chemical analyses of the various soils in the Area could not be undertaken, nor has it been possible to make a study of root habits.

INSTRUMENTS USED.

1. For line transects,—surveyor's steel tape, 300 Cape feet in length.
2. For belt transects,—pair of surveyor's chains (60 Cape feet), with lengths of thin cord stretched between them at suitable intervals.
3. For quadrats,—lengths of galvanised strap-iron, arranged in squares of 1 m. side (*v.* Weaver and Clements, 1929).
4. Photography,—Voigtländer " Brilliant " camera, F/4 ·5, and Voigtländer quarter-plate camera, F/6 ·3.
5. Temperature readings,—ordinary centigrade thermometers.
6. Humidity readings,—wet-and-dry bulb whirling hygrometer.
7. Wind velocities,—Birma's Fan-Anemometer.
8. Light intensities,—Imperial Exposure Meter.
9. For measurement of evaporation,—evaporimeters constructed on the plan of Pickering's Standard instrument. The reservoirs were graduated in ccs., and to prevent heating of the water they were placed in polished metal containers (cocoa tins) and packed with sawdust.
10. For determining the angle of slope,—Gallenkamp's combined Theodolite-Sextant-Clinometer.
11. For determining soil reaction,—B. D. H. Soil Testing Outfit.
12. For water-content determinations,—electric drying oven.

SECTION II.

(*a*) CLIMATE.

The climate is one of summer rains, and, like that of the greater portion of the Orange Free State, it is of a very rigorous nature. Cold, dry winters are succeeded by long, hot summers with a low rainfall. Long periods of heat and drought are generally followed by heavy showers of rain—from 1 to 1½ inches may fall in the course of an hour—which cause considerable erosion as shown in Plate 9A. Hail is of frequent occurrence, causing much damage to orchards, crops and gardens, but snow is very rare, four light falls having been recorded during the past 22 years.

The average annual precipitation during the period 1916-1933 was 20·19 inches ; during the period 1928-1933 it was only 16·89 inches, and, as seen in Table 1 the number of rainy days in each year is very small. From the table it will be seen that spring rains are scanty. In response to the rise in temperature in spring, the grasses may commence growth, and become green, but they are very soon withered and browned by heat and drought, and remain so until the first rains of summer. In this season, too, prolonged periods of drought are of yearly occurrence, and it is very seldom that the herbaceous vegetation remains green throughout a summer.

Great extremes of temperature are experienced in the Bloemfontein district (*v.* Table 2) ; temperatures above 70° F. may be reached during the day in mid-winter, and at night they may fall below 15° F. In summer, insolation is intense ; air temperatures of 90° F. are frequent, while soil temperatures, at a depth of 2 inches, may rise above 107° F. (42° C.). High temperatures in summer are usually accompanied by low atmospheric humidity—in 1933 the average daily humidity during the summer months was in the neighbourhood of 27%, while temperatures soared well above 90° F. (*v.* Table 2)—causing thus excessive evaporation. The ratio, evaporation/rainfall of the same year was 84/14 (inches) ; the normal ratio, however, is about 70/20.

Winter is a dangerous period for plants ; often in mid-winter, warm days are succeeded by intense cold at night, and short periods of warm, sunny days, and frost-free nights may be followed by periods of low temperature and severe frost. A succession of frosty nights frequently occurs in spring, after deciduous plants have already donned their foliage —in 1935, frost was recorded as late in the season as November 17th.

During late winter, spring, and frequently during the summer months, the vegetation is subjected to hot, drying winds which sweep across from the arid west. During summer, more or less localised cyclonic winds are prevalent. These pass through all points of the compass in the

TABLE I

RAINFALL

(INCHES)

STATION : BLOEMFONTEIN.
LAT.: 29° 07′ S.
LONG.: 26° 12′ E.

Year.	Jan.		Feb.		Mar.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Year.		Summer. (Oct.-Mar.) Inches.	Winter. (April-Sept.) Inches.
	In.	Dys.	In.	Dys.	In.	Dys.	In.	Dys.	In.	Dys.	In.	Dys.	In.	Dys.	In.	Dys.	In.	Dys.	In.	Dys.	In.	Dys.	In.	Dys.	In.	Dys.	Days.	Days.
1930	2·32	10	1·91	6	3·06	7	2·17	7	0·65	1	0·14	2	0·00	0	0·13	3	0·00	0	0·38	2	0·40	4	1·19	7	12·35	49	9·26 36	3·09 13
1931	6·34	14	2·52	11	2·70	11	4·15	11	0·00	0	0·02	1	1·80	4	0·14	1	0·00	0	1·59	5	3·25	8	0·52	4	23·03	70	16·92 53	6·11 17
1932	1·68	3	2·75	10	2·98	9	0·00	0	0·11	1	0·00	0	0·01	1	0·00	0	2·28	3	1·63	6	0·98	6	2·37	5	14·79	44	12·39 39	2·40 5
1933	0·58	6	1·36	5	1·47	6	1·07	4	0·16	1	0·09	2	0·00	0	0·19	2	0·00	0	0.24	1	5·46	14	4·64	8	15·26	49	13·75 40	1·51 9
1934	5·03	15	3·53	11	2·15	11	1·57	5	1·22	7	0·00	0	0·43	3	0·09	2	0·09	1	2·33	5	2·18	8	2·53	7	21·15	75	17·75 57	3·40 18
Means	3·19	9·6	2·41	8·6	2·47	8·8	1·79	5·4	0·43	2	0·05	1	0·45	1·6	0·11	1·6	0·47	0·8	1·23	3·8	2·45	8	2·25	6·2	17·32	57·4	14·01 45	3·30 12·4

TABLE II

TEMPERATURES (°F).

Station : Bloemfontein.
Lat.: 29° 07′ S.
Long.: 26° 12′ E.

Year.	January.		February.		March.		April.		May.		June.		July.		August.		September		October.		November.		December.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1930 Mean	83·4	58.8	84·0	56·7	79·7	54·8	71·5	45·3	67·8	36·8	59·6	32·3	63·2	32·3	64·5	34·9	70·8	38·2	79·1	52·5	85·3	57·1	88·2	60·1
1930 Absolute	90·1	50·0	97·1	45·1	90·7	42·7	79·4	34·0	73·4	28·0	63·0	25·2	69·3	26·0	75·8	26·5	84·5	27·4	92·2	35·2	95·2	46·9	90·0	42·4
1931 Mean	84·4	61·0	84·4	60·7	80·6	57·8	68·4	47·4	70·3	40·3	61·4	32·1	57·0	32·8	67·6	36·2	72·1	42·1	78·1	49·4	79·5	56·3	88·0	56·5
1931 Absolute	92·2	51·2	90·5	56·7	88·0	49·6	83·1	34·8	77·2	28·4	67·5	17·6	69·0	24·1	79·1	24·2	84·8	25·9	94·8	37·1	91·6	50·4	94·3	51·0
1932 Mean	86·2	57·3	83·4	59·8	79·4	57·8	79·1	52·2	69·0	43·6	63·6	28·8	61·3	29·6	69·7	33·8	73·2	45·3	79·5	52·9	84·0	53·8	87·0	57·0
1932 Absolute	99·0	44·7	91·3	50·4	86·5	48·8	83·4	42·1	74·9	33·6	68·4	22·7	71·0	22·3	81·1	26·8	84·0	33·0	90·0	39·2	95·6	45·0	95·2	41·5
1933 Mean	88·6	61·5	88·9	61·1	84·4	56·6	75·1	47·2	70·5	37·3	58·1	27·0	62·4	31·2	67·8	36·2	74·9	45·0	82·2	49·2	77·4	55·7	81·0	59·4
1933 Absolute	96·0	56·6	94·6	53·8	90·8	48·3	84·8	36·7	80·8	23·2	69·5	14·4	71·5	19·0	74·7	26·3	86·6	34·0	93·0	36·6	84·9	44·0	93·0	52·0
1934 Mean	78·5	59·6	79·4	56·0	78·3	53·3	74·0	47·9	70·0	40·6	65·2	34·0	61·7	31·3	69·7	37·0	75·1	41·6	78·5	48·3	79·5	55·2	81·6	56·5
1934 Absolute	86·8	52·3	90·9	43·5	85·9	38·9	85·8	35·6	80·0	34·2	70·5	27·2	74·6	17·7	78·5	23·8	87·6	29·0	96·5	37·2	87·9	44·0	90·6	48·6
Means	88·5	55·3	88·5	54·4	84·4	79·3	78·5	42·3	73·4	35·7	63·7	26·1	66·4	26·6	72·8	47·6	79·4	36·1	86·4	43·4	86·1	50·9	89·2	52·5

course of a single day ; arising in the early morning in the east or south-east, they veer through north, to west, by noon, and by sunset they are sweeping across from the south, shortly after which they generally cease. Prolonged winds from the north and north-east are usually followed by precipitation, but these winds are infrequent.

Owing to the severe climate the vegetation is mostly xerophytic in character. Trees are somewhat poorly represented, occurring only in situations where, due to topography, the conditions of soil-depth and water-supply are more favourable, viz., on southern faces of koppies, south-facing sides of valleys, along spruits in the valley bottoms, and along the sides of rocky dongas among the koppies.

For other aspects of the climate of Bloemfontein *v.* Potts (1922, pp. 147-154.)

(*b*) GEOLOGY AND TOPOGRAPHY.

The Area consists of a doleritic boss which overlies rocks of the Beaufort Series. Owing to the weathering of the dolerite, the Area has become honeycombed by a network of valleys and dongas, traversed by dry spruits and sloots, leaving between them raised masses—the koppies and bults. The site is thus of a very irregular and broken nature (Plate 6A) with sharp transitions between the various levels and offers many and varied habitats. This is reflected in the number of different plant communities found, and in the richness of the flora.

(*c*) SOILS.

The soils are all of doleritic origin. Their exceptional shallowness, on the whole, is an outstanding feature of the Area. The only situations which possess soils of any appreciable depth are (*a*) the valleys and depressions containing deep alluvial deposits, which, in the valleys, may reach a depth of over 40 feet ; and (*b*) the southern faces of koppies, and south-facing sides of valleys with steep talus slopes. (The actual depth of the talus is difficult to estimate.) For the rest, as already mentioned, the soils are exceptionally shallow ; on the bults, for example, they seldom exceed a depth of 9 inches.

A very large proportion of the soil, formed on the bults and koppies from the weathering of the rock, is washed down by heavy showers of rain into the valleys and depressions.

The soils of the koppies and bults are brown ; they are of a coarse, gravelly or sandy nature, and show a neutral reaction. Those of the depressions and valleys, on the other hand, are of the dark-coloured turf type, with a fairly high clay content (as seen from their plasticity when wet), and slightly acid reaction. The soils of the bush-covered talus slopes are also dark in colour, but they show a neutral reaction ; their dark colour is due to humus.

(*d*) EFFECTS OF MAN.

Relative to the density of the population, the effects of man are not very great ; the vegetation still persists, in places, in what seems to be an almost natural condition. The nature of the topography and of the soils does not permit of extensive cultivation ; small cultivated areas are restricted generally to depressions and valley bottoms, where the soil is deep and uniform. It is essentially a stock-farming area, and the disturbances caused by man, therefore, are chiefly due to his grazing animals, which, as will be seen in the following section, have assisted in causing certain changes to take place in the vegetation.

Here and there man has produced slight changes in the topography. By the damming of sloots in gullies considerable depths of soil have been built up by silting. The new scheme of Government assistance to farmers, for the conservation of soil and water, bids fair to bring about marked changes in the physiognomy of the lower-lying areas. Adv. C. A. Beck, for example, has recently taken advantage of this assistance, and has converted a series of dongas, spruits and sloots, on Bayswater (Map 1) into an extensive system of water conservation. Where earlier there was but a dry system of spruits and water-courses, there exists now a series of bodies of permanent water (not shown on the map) and this is bound to cause, in time, considerable change in the vegetation of the affected areas.

SECTION III.

THE VEGETATION.

(*a*) GENERAL ACCOUNT.

Within the Area there are distinguished 3 major types of vegetation : scrub, bush and grassland. These are further subdivided into 9 associations : scrub 5, bush 3 and grassland 1. (Map 1.)

Scrub.

This is by far the most extensive of the three types. It occupies approximately 92% of the total vegetational cover of the site, extending over all the higher areas except the slopes of koppies, and sides of valleys which face south and south-east ; on these it is generally ousted by bush. On eastern faces, too, scrub is occasionally displaced by small patches of bush.

Scrub comprises the following 5 associations :—

(1) *Mesembryanthemum spinosum—Euphorbia mauritanica*,
(2) *Euryops sulcatus—Euphorbia mauritanica*,
(3) *Euryops sulcatus—Themeda triandra*,
(4) *Koppie scrub*, and
(5) *Rhus ciliata—Themeda triandra.*

Bush.

Bush is less extensively developed than scrub, occupying but 6% of the total vegetational cover. It is almost wholly confined to the slopes of koppies and sides of valleys which face south or south-east, to the sides of dongas, and to valley bottoms (*v.* Plate 8). As previously mentioned, however, small patches of bush occasionally extend to eastern faces of slopes, especially where these are steep.

Bush comprises 3 associations : koppie bush, spruitbank-valley bush, and Acacia bush.

Grassland.

Pure grassland is represented in the Area by one association, valley grassland. This is more luxuriant than and differs somewhat in composition from the grassveld surrounding the Area. It occurs only in depressions, in deep soil varying from 4 to over 20 feet in depth. It is found (*a*) following watercourses which wander down from the upper levels, (*b*) occupying small flushes (seasonal vleis) and (*c*) among bush clumps in the valleys. The association occupies the remaining 2% of the vegetational cover of the Area.

(*b*) THE ASSOCIATIONS.

(The Roman numerals I-VIII, including IVa, in Map 1 mark the points at which transects, Figs. I-VIII, were made.)

1. *Mesembryanthemum spinosum—Euphorbia mauritanica.*

(Plate 7A, and Fig. I.)

This association is a succulent scrub characterised by the two dominant plants, *M. spinosum* and *E. mauritanica*. Through it is sometimes scattered, too, the hard-leaved or sclerophyllous *Euryops sulcatus*. The association inhabits very rocky areas on the bults, where there is virtually no soil-cover except in small patches in shallow pockets and depressions in the rock. Large portions of the bults are so constituted; the roots of the shrubs penetrate and ramble among interstices of the rock.

Very characteristic of the association, but less conspicuous than the above plants on account of its smaller stature (6 in.—8 in.), is the dwarf-shrub *Eriocephalus spinescens*, while the suffrutescent *Sutera argentea* is also a common component. In rock crevices, among the dominant plants, are typically present tufts of several species of cleft-inhabiting, or chasmophytic grasses. Chief among these are *Eustachys paspaloides*, *Rhynchelytrum roseum* and *Aristida Burkei*. Occasionally inhabiting these crevices, too, are the ferns *Notholaena Eckloniana* and *Pellaea hastata*, as well as isolated tufts of the grasses *Digitaria eriantha* and *Themeda triandra*. Between the exposed sheets of rock are situated small patches of shallow (½ in.—1½ in.) soil, bound by colonies of short, xerophytic grasses, chief of which is *Eragrostis denudata* (*v.* Fig. I) which forms short (3 in.—5½ in.), closed communities in these situations. Other grasses are *Lepturella capensis*, *Microchloa caffra*, *Tragus koelerioides*, *Eragrostis obtusa* and *Eragrostis* sp. nr. *Atherstonei*. *Aristida barbicollis* and *A. congesta* are commonly represented, while the composite *Geigeria passerinoides*, and the sedge *Mariscus capensis* are characteristic, associated plants of such situations. Among these plants, in the shallow soil-patches, is commonly found a small species of the liverwort genus Riccia. This plant forms fairly extensive mats, and the rhizoids form a dense weft in the surface ¼ in. of soil, binding it strongly against erosion. These mats, when dry, impart to the soil a characteristic black, scaly appearance, similar to that produced by excess sodium carbonate (black brak). An important coloniser of small gravel patches formed between the rock outcrops, is the succulent *Stomatium mustellinum*, which forms small, isolated cushions (3 in.—6 in. diam. and 1 in.—2 in. height) seen in Plate 7B. Important pioneers of these coarse gravel areas, also, are the succulents *Ruschia unidens* and

Anacampseros ustulata, while the small tufted grass, *Lepturella capensis* (Plate 7B) is likewise a significant occupant. Here, too, after the first rains of spring, or early summer, spring up and flower Anthericum spp., Dipcadi spp., Eriospermum spp., *Symplegma pulchellum* and other small liliaceous plants, which remain in evidence for but a short while, their aerial parts shrivelling and disappearing upon the advent of summer heat and drought.

Mesembryanthemum spinosum, a rigid shrub, collects wind-blown sand and litter, building up around its base a mound of humous soil. This proves a fertile seed-bed to wandering disseminules which collect there. Being in addition spiny, it acts as a protector, turning away browsing animals, and in its shelter small colonies of other plants, which are seldom met with elsewhere, are developed, as shown in Fig. I. These are *Kleinia radicans*, which produces a prostrate, succulent tangle around the base of *M. spinosum*, interlacing with its lower branches; *Sarcostemma viminale*, which straggles up through the branches, producing in late summer a creamy profusion of blooms; and *Heliophila suavissima* which grows up through the protecting shrub, erecting its violet flowers above. *Sarcostemma viminale* and *Kleinia radicans* do occasionally inhabit other situations; they are found in rock clefts especially, where the former is generally browsed off level with the outer surface of the cleft.

The mounds of soil built up around the base of *M. spinosum* often support as well, small clans of *Cotyledon trigyna*, *Crassula platyphylla*, *Stapelia flavirostris*, *Caralluma lutea*, *Duvalia Corderoyi* and individuals of *Cotyledon decussata*, *Crassula fruticulosa* and *Sutera coerulea*. Occurring here, too, are single tussocks of *Aristida Burkei*, *Eustachys paspaloides*, *Themeda triandra*, *Digitaria eriantha*, an occasional *Cymbopogon plurinodis* and young individuals of *Euphorbia mauritanica*.

2. *Euryops sulcatus—Euphorbia mauritanica.*

This association (Plate 8, and Fig. II) does not differ greatly from the previous one, but, owing to its occupation of somewhat different conditions of soil, certain species, characteristic of the former association, are absent from, or but poorly represented in it, while others that are relatively insignificant in the former, assume here greater significance.

The association is also an inhabitant of the bults, but it occupies slopes less steep than those inhabited by *Mesembryanthemum spinosum—Euphorbia mauritanica*; erosion is less severe, and there is, therefore, a more uniform layer of soil covering the rock, outcrops of which are far less numerous.

With the increase in soil-cover, the grasses, which are of minor significance in *M. spinosum—E. mauritanica*, become much more prominent, and the role of *M. spinosum* in the association is taken over by *Euryops sulcatus*. The grasses (Plate 8) are chiefly *Eragrostis Lehmanniana*, *E. obtusa*, E. sp. nr. *Atherstonei*, *Aristida barbicollis*, *Aristida congesta*, *A. Burkei*, *Digitaria eriantha*, *Themeda triandra*, and in shallower ($1\frac{1}{2}$ in.—2 in.) patches, societies of *Eragrostis denudata* are frequent.

Absent from, or rare in this association, but well represented in *M. spinosum—E. mauritanica*, are the rock-plants *Cotyledon decussata*, *Cotyledon trigyna*, *Crassula platyphylla*, *Stapelia flavirostris*, *Duvalia Corderoyi*, *Caralluma lutea* and *Sarcostemma viminale*. *Heliophila suavissima* occasionally occurs in the shelter of *Euphorbia mauritanica*. Mats of Riccia sp. are abundant among the grasses, while *Geigeria passerinoides* and *Mariscus capensis* are well represented in the association.

3. *Euryops sulcatus—Themeda triandra.*

This association (Plate 9A and Fig. III) occupies two types of habitat, but in both cases it inhabits deeper soil than either of the two preceding associations. It occurs (*a*) on the bults, on slopes only slightly inclined, in brown soil of about 9 inches to $1\frac{1}{2}$ feet in depth ; and (*b*) at lower levels, in depressions and basins, in dark-coloured, alluvial soil ranging in depth from several to over 15 feet. The association is represented, also, in one or two places, on level summits of koppies, where the conditions of soil are similar to those of its bult abode,

Typically, the association is composed of a somewhat mixed Themeda grassveld in which are scattered numerous individuals of *Euryops sulcatus*. With the better development of grass, a number of associated grassveld plants enter the association, *e.g.*, Aster spp., Helichrysum spp., Asclepias spp., *Melolobium candicans*, *Scabiosa columbaria*, Ipomoea spp., *Convolvulus ulosepalus*, *Boerhaavia pentandra*, Hibiscus spp., Hermannia spp., *Brunsvigia grandiflora*, and others.

4. *Koppie scrub.*

The fourth and most prominent association (*v.* Map 1) is koppie scrub (Figs. IV and IVA). It generally extends over the summits of koppies and over koppie slopes and valley sides facing north, east and west. Koppie scrub occurs, also, on south-facing slopes, wherever bush is absent. It inhabits shallow talus, the actual depth of which is difficult to ascertain. These situations support a heterogeneous assembly of plants (Fig. IV). All the members of the first two associations are represented here, together with a sprinkling of stunted trees and a number of shrubby forms, more or less restricted to these habitats.

Owing to the local differences in aspect of the habitat—discussed in division (*d*) of this section—koppie scrub shows large variations in the density of its various constituents, but the general constitution of the association remains constant.

The trees found in koppie scrub are mainly stunted individuals of *Olea verrucosa*, *Chilianthus arboreus*, *Euclea lancea*, *Royena microphylla*, *Osyris compressa*, *Ehretia hottentotica* (*rigida*), *Grewia occidentalis*, and *Gymnosporia polyacantha*. Species more or less restricted to the association are *Rhigozum obovatum*, which occasionally forms open societies (Fig. IVA) on the summits, and upper slopes of koppies ; *Euclea ovata*, which seldom exceeds a height of 4 feet, being constantly browsed by stock ; *Rhus Burchellii*, rarely found in koppie bush ; *Euryops multifidus*, almost entirely restricted to koppie scrub ; and *Pachypodium succulentum*, found in rocky situations on the summits of koppies. Though a dominant of *Rhus ciliata—Themeda triandra*, the former plant is a prominent member of koppie scrub. A rich variety of grasses is present in the association ; all those mentioned for the previous communities, together with a number of additional species, such as *Enneapogon scoparius*, *Eragrostis superba*, *Heteropogon contortus*, *Triraphis andropogonoides*, *Trichoneura grandiglumis*, and a few others. Chomophytes are well represented ; the number of individuals is large. The most important are : *Notholaena Eckloniana*, *Pellaea hastata*, *Sarcostemma viminale*, *Cotyledon trigyna*, *Anacampseros telephiastrum*, *A. filamentosa*, *Indigofera Zeyheri*, *Euphorbia aspericaulis*, *E. caterviflora*, *Phyllanthus maderaspatensis* and *Kleinia radicans*. Very characteristic of the association is *Aloe grandidentata* which forms numerous small clans on koppie slopes and summits ; their clusters of flame-coloured flowers, in winter, go far towards relieving the monotony of the view. Small, stunted individuals of *Olea verrucosa* often play here the same role as *Mesembryanthemum spinosum* (see *Mesembryanthemum spinosum—Euphorbia mauritanica*) in encouraging the development of colonies of *Kleinia radicans* and *Sarcostemma viminale* within their shelter.

5. *Rhus ciliata—Themeda triandra.*

This association (Plate 9B) occupies the lower slopes of koppies, and fringes the outer edges of bults, abutting on the grassveld surrounding the Area. It is found, occasionally towards the interior of the Area (*vide* Map 1), on the lower slopes of koppies where the soil is more uniform, favouring the development of grassveld.

The association is simple in composition, and similar in form and habit, to *Euryops sulcatus—Themeda triandra*. It is composed of a mixed *Themeda* grassveld in which are unevenly scattered, at intervals ranging from a few feet to more than 20 yards, individuals and clumps of *Rhus ciliata*, from 2 to 4 feet in height and 3 to 12 feet diameter. Associated with the grasses are the usual grassveld plants enumerated for the *Euryops sulcatus—Themeda triandra* association.

6. *Koppie Bush.*

On steep* slopes of koppies and valleys, facing south and south-east, and along the sides of rocky dongas among the koppies, the trees of koppie scrub have developed, to the exclusion of the other scrub members, to form semi-close stands of bush. As mentioned earlier in this paper small stands of koppie bush occasionally occur also on east-facing slopes, where these are steeply inclined. The association always inhabits deep talus.

From Fig. V it is seen that koppie bush forms a semi-close community in which *Olea verrucosa*, *Chilianthus arboreus*, *Cussonia paniculata* and *Grewia occidentalis* are the chief trees. The crowns of *O. verrucosa*, *C. arboreus* and *G. occidentalis* form a more or less broken canopy, 10 to 14 feet in height, and grey-green in colour. Through it protrude, at varying intervals, the paler blue-green crowns of *Cussonia paniculata* (14 ft.—16 ft. height). *Heteromorpha arborescens* and *Euclea lanceolata* are also represented in the bush.

The association is possessed of a fairly rich undergrowth. Beneath the crowns of the trees are found numerous plants of all sizes ; these can be grouped into two layers (Fig. V) (*a*) those between 3½ and 6½ feet in height, comprising saplings of the trees forming the upper layer, the small trees (or tall shrubs) *Gymnosporia polyacantha* and *Ehretia hottentotica* and the shade-plant *Cluytia pulchella;* and (*b*) those below 3½ feet : seedlings of the trees and shrubs and herbaceous plants.

With the development of bush a number of sciophilous (shade-loving) species have made their appearance. These are : *Solanum nigrum*, *Cluytia pulchella*, *Eucomis undulata* (a shade-plant of tall grass), *Crassula nodulosa*, *Crassula Cooperi* var. *robusta*, and the grasses *Panicum deustum*, *Ehrharta erecta* and *Setaria verticillata*. Here, too, occur Asparagus spp., *Kleinia radicans*, and *Sarcostemma viminale*. In late summer and in autumn the floor of the bush becomes clothed by dense stands of the small *Crassula muscosa*. Rock-surfaces and crevices are inhabited by numerous Cyanophyceae, small crustaceous lichens, the liverworts, *Targionia hypophylla*, *Fimbriaria marginata*, *Plagiochasma rupestre*, *Fossombronia pusilla*, Riccia spp., *Trichostomum brachystomum* and a few others, several shade-loving ferns, especially *Cheilanthes hirta* and

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* By " steep " is meant a slope of 25°—30° to the horizontal.

Ceterach cordatum, and the mosses Bryum spp., *Ptychomitrium cucullatifolium*, *Tortula pilifera*, *T. atroviridis*, Entosthodon spp., and several undetermined species.

The trunks of the trees, especially those of *Olea verrucosa*, are often sparsely clothed by several species of crustaceous lichens. Olea often bears on its branches a number of individuals of the parasite *Viscum pauciflorum*.

Owing to the interrupted nature of the canopy a number of typically heliophilous species enter koppie bush, occupying the illuminated patches of the floor ; these are *Crassula platyphylla*, *Cotyledon trigyna*, *C. decussata*, *Aloe grandidentata* (very much etiolated) and *Stapelia flavirostris*.

On the whole the shade cast by koppie bush is not dense ; the average light intensity for the association, as calculated from 15 readings taken in January, in several different stands, was 13.33 per cent. of full sunlight.

7. *Spruit-bank-valley bush.*

As the rocky dongas are descended, and the deep alluvial soils of the valleys encountered, koppie bush becomes mixed with, and finally gives way to a new bush community, which we have called spruit-bank-valley bush (Plates 6A, 10A, Fig. VI, Map 1). The soil may reach a depth here of over 25 feet. *Olea verrucosa* still persists in the association as an important member ; *Gymnosporia polyacantha* is also a component, while an occasional *Chilianthus arboreus* is found to stray into the community.

Spruit-bank-valley bush, as its name suggests, clothes the banks of spruits and sloots which wander down the valleys. Isolated clumps of this bush are found also dotted about the valley floors, giving to them a park-like appearance (Plate 6A). The bush lining the banks of the spruits forms an irregular, usually open community (Plate 10A), but in a few places it forms closed communities (Fig. VI). The association is built up of a number of species of trees which vary considerably as to height ; and it cannot be said that any particular species are dominant for the association as a whole. Some are more conspicuous than others by reason of their superior stature ; *Celtis rhamnifolia* occasionally exceeds a height of 25 feet, *Rhus lancea* may attain to 20 feet or more, and in rare instances individuals of *Zizyphus mucronata* of about the same height have been recorded, while *Olea verrucosa* often reaches a height of 18 feet along the spruits. For the rest the bush seldom exceeds a height of 12 feet.

The bush clumps dotted about the valley floors are usually dominated by one or two large individuals of *Celtis rhamnifolia*, *Zizyphus mucronata*, or *Rhus lancea* ; beneath and around these is developed a dense, interlocked growth of *Royena decidua*, *Rhus pyroides*, young trees of *Zizyphus* *mucronata*, and an occasional *Olea verrucosa.* In the areas between the clumps are usually developed luxuriant glades of valley grassland. Around the fringes of the clumps and scattered through the grass glades is found the " wildeals " (*Artemisia afra*). So prominent was this plant at one time that the farm Wildealskloof* (*v.* Map 1) was named after it.

The shade cast by closed portions of the bush is dense (4.81 per cent. of full sunlight). The ground vegetation is, as a result, rather sparse (*v.* Fig. VI). The undergrowth is composed chiefly of seedlings and saplings of the trees, seedlings and young plants of the liane *Clematis Thunbergii*, species of Asparagus, scattered individuals of *Senecio glanduloso-pilosus*, *Achyranthes aspera*, *Solanum nigrum*, *Tagetes minuta* and the grass *Ehrharta erecta.*

Clematis Thunbergii is very well developed in the association, and often seriously threatens the well-being of the trees supporting it. Very richly developed, too, is the parasite *Viscum pauciflorum* which shows a marked preference for *Olea verrucosa.* *Rhus lancea*, it has been noticed, is always free from the parasite, and seeds of Viscum placed on this host have not germinated.

8. *Acacia bush.*

(Plates 10B, 11 and Fig. VII).

Near the mouths of the valleys, where the gradient is slight, the spruits are considerably reduced in depth and in width ; small flushes are formed, and the soil may reach depths of over 40 feet. As the flushes are approached from the upper reaches of the valleys, spruit-bank-valley bush rapidly gives way to Acacia bush (*v.* Map 1). Plate 10B shows a stand of this bush following a flush.

Acacia bush is relatively simple in composition (*vide* Fig. VII†); it is composed of closed stands of *Acacia karroo*, and beneath the trees is a ground vegetation, poor in species. The trees are from 14 to 20 feet in height, their crowns are by no means densely branched (Plate 11) and the shade cast by them is, in consequence, less deep than that of the above association ; the average light intensity for the community, observed in January, was 10·03 per cent. full sunlight.

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* The Wildealskloof of to-day is the remnant of a large farm of this name, which originally comprised, as well, the farms Stathearn, Tredenham and Mooihoek.

† The small stand of bush marked by the Figure VII in Map 1 was chosen for the transect on account of its undisturbed condition, due to its having been fenced off from stock since 1915. Much damage is done by stock to the ground vegetation of Acacia bush in other locations.

Owing to the more favourable intensity of light, further augmented by the deciduous nature of *Acacia karroo*, the bush floor is covered by close stands of the grasses *Bromus unioloides*, *Ehrharta erecta* and tussocks of *Panicum deustum*. For the rest the undergrowth is comprised of seedlings and saplings of *Celtis rhamnifolia*, *Zizyphus mucronata*, *Rhus lancea*, *Rhus pyroides*, *Royena decidua* ; of the shade-plants, *Solanum nigrum*, *Achyranthes aspera*, Asparagus spp., Lycium sp., and *Tagetes minuta*. Seedlings and saplings of *Acacia karroo* are rarely encountered ; the reason for their absence is discussed in division (*d*) of this section.

9. *Valley grassland.*

As previously noted valley grassland occupies the sides of water-courses, small flushes (where Acacia bush is not developed), and areas between the clumps of bush in the valleys. In general, the association is of a hygro-mesophytic nature, forming luxuriant stands in normal seasons. It is composed chiefly of the grasses *Eragrostis nebulosa*, *Panicum minus* var. *planifolium*, *Pennisetum sphacelatum*, *Diplachne fusca*, *Eragrostis plana*, *E. margaritacea*, *Themeda triandra* and *Sporobolus fimbriatus*, with an occasional tussock of *Cymbopogon plurinodis* ; the sedges Scirpus spp., Cyperus spp., Mariscus spp., and two species of Juncus, *J. rupestris* and *J. exsertus*, are frequently represented. When in flower the grasses vary in height from 3 to 5 feet. Where the grass is closely cropped, numerous herbaceous plants—especially prominent in spring—are found associated with the grasses. Some of these are Lobelia spp., *Wahlenbergia arenaria*, *W. nudicaulis*, Helichrysum spp., *Ifloga paronychioides*, Sebaea spp., *Diclis petiolaris*, *Manulea Benthamiana*, *Anchusa capensis*, Oldenlandia (*Hedyotis stricta*), *Tournefortia tuberculosa*, *Scabiosa columbaria*, the half-shrub *Sida cordifola* and the geophytes *Homeria pallida*, *H. aurantiaca*, Moraea spp., Bulbine spp., Anthericum spp., Scilla spp., and *Gladiolus edulis*. *Eucomis undulata* occurs as a shade plant in tall grass.

(*c*) THE RELATIONSHIPS OF THE ASSOCIATIONS.

Starting from bare rock on the one hand and from water on the other, and assuming that succession always tends towards the mesophytic one can theoretically connect up most of the associations of the Area in two series converging into Themeda Grassveld. Such a dynamic scheme (*v.* Phillips, 1930) if correct would be a useful guide, but sufficient evidence has not yet been obtained from the vegetation to enable such a scheme to be drafted. There are too many gaps in the evidence, and some of the evidence seems conflicting. For instance the habitat of Acacia bush seems more favourable to plant growth than that of the Spruit-bank-valley bush, and the Acacia bush gives the general impression of being dynamically a more advanced community. Yet it is being invaded by members of the other association. The cutting of firewood from the Acacia bush and the influence of grazing animals may be determining factors, but this is not yet certain. From the evidence of local farmers this displacement is known to have happened before, but again the effect of man's interference is uncertain.

(*d*) FACTORS.

Mesembryanthemum spinosum—Euphorbia mauritanica.

This association occupies the most adverse habitat to be found in the Area. The small patches of soil on the rocky slopes are exceedingly shallow, and composed of coarse sand and gravel ; their water-retaining capacity is consequently very low and the run-off is enormous. The slopes are fully exposed to the desiccating effects of sun and wind. The effect of insolation is intensified by the shallowness of the soil and the abundance of exposed rock-surfaces. Soil temperatures above 40°C. have been recorded in summer while the temperature of rock-faces may rise above 60°C. Only the most hardy and highly adapted plants are able to endure on these slopes. *Mesembryanthemum spinosum*, though a leaf-succulent, sheds about two-thirds of its foliage during hot, rainless periods ; *Euryops sulcatus* retains only its youngest leaves—the branches being naked usually to within a few inches of the tips ; and *Euphorbia mauritanica*, a stem-succulent, sheds its leaves shortly after their development in spring. During periods of heat and drought, growth of the vegetation ceases, the grasses shrivel and brown, and the association, as a whole, enters into a state of suspended animation.

Euryops sulcatus—Euphorbia mauritanica.

The habitat conditions of this association are essentially similar to those of the previous one ; the slopes, however, are less steep with the result that run-off and consequent erosion is less severe. As a result there is a more uniform and somewhat deeper soil-cover on these slopes, and it is this factor which determines the differences in the vegetation of the two associations. The more uniform soil-cover encourages stronger development of grasses, and although we have found no direct evidence to this effect, it is probably due to the richer grass development that *Mesembryanthemum spinosum*—a plant sensitive to shading—is absent from the association.

Euryops sulcatus—Themeda triandra.

As mentioned earlier in this paper, *Euryops sulcatus—Themeda triandra* inhabits deeper soil than either of the above two associations. The deeper soil and consequent higher water-capacity has caused the development of a good growth of grass which apparently is responsible for the exclusion of *Euphorbia mauritanica.* It has been noted also, that the association inhabits two types of soil : (1) brown, sandy soil on bults, 9 inches to 1½ feet deep ; and (2) dark, alluvial soil in basins and depressions, sometimes over 15 feet deep. Evidence suggests that the original abode of *Euryops sulcatus* was on the bults, and that the influence of man, combined with periodic droughts has been responsible for its recent spread into the lower levels which originally supported pure grassland. Several of the older inhabitants of the Area have been questioned concerning the distribution of *Euryops* in the past, and although the information obtained from this source is somewhat vague and conflicting, the general impressions appear to be in accordance with what has just been said.

The chief factor encouraging the spread of *Euryops* is man. His herds and flocks, by grazing off, and trampling out the grass, enable the resin-bush, which is highly unpalatable to stock, to penetrate readily into the valleys from which it was formerly kept out by the luxuriance of the grass. The invasion of *Euryops* is greatly facilitated by its flowering habit ; it flowers abundantly and produces seed copiously after every rain, in winter as well as in summer. Plate 9A shows a heavily-grazed portion of grass-veld in which *Euryops sulcatus* has become thickly established. From its situation, viz., low-lying area with deep alluvial soil, watered from the upper slopes, one is led to suppose that the site originally supported valley grassland. In some instances *Euryops* has penetrated into bush communities in the valleys.

An interesting parallel to the behaviour and spread of *Euryops sulcatus* in the Area has been reported from a certain farm in the Thaba 'Nchu district, which, due to over-stocking and burning, has recently become heavily invaded by the resin-bush.

During the past two years, in areas that have been protected from stock, or only lightly grazed (Fig. III) the grass has made luxuriant growth, and threatens to "choke out" the resin-bush. If these areas are protected for several more years it is quite probable that *Euryops* will be completely ousted. On the bults, however, the drier conditions are less suitable to a dense development of grass, so that here an equilibrium is established between *Euryops* and *Themeda.*

Koppie Scrub.

Except for the eastern faces of koppies which are more protected and which frequently have developed on them small patches of bush, koppie scrub inhabits, in point of exposure to insolation and to drying winds, situations as adverse as those of the first two associations dealt with. The factor responsible for its richer development, both in number of species and of individuals, is the depth of the soil; this is a shallow talus of uncertain depth, but nevertheless considerably deeper than the soils of the above two associations.

As previously noted, koppie scrub varies in density according to its particular aspect. On easterly slopes insolation is less intense with the result that a closer growth of trees and shrubs takes place, and it may even proceed to bush. On north-westerly slopes, on the other hand, the drying effects of wind and sun are more intense, and erosion more severe. Here, a richer development of the succulent scrub and of xerophytic grasses, notably *Aristidas* and species of *Eragrostis*, is usually found.

Rhus ciliata—Themeda triandra.

This community is in a rather disturbed state; over-stocking, combined with the recent severe droughts has led largely to the replacement of *Themeda* by species of *Aristida* and *Eragrostis.* As Bews (1918) puts it, the grassveld has been thrown back to the earlier stages of the succession. *Themeda triandra* is, however, again making rapid advance on situations where grazing is not severe.

Koppie Bush.

The restriction of koppie bush to slopes facing south or south-east, and its almost complete absence from other slopes is a striking feature of the Area. Plates 12A, 12B and Fig. X illustrate this. The differences between the vegetation of slopes facing south and of those facing north have attracted the attention of ecologists in many countries. These differences are generally attributed to the differences in climate found on the slopes, but whether the climate is the direct factor, or whether it is only indirectly responsible, is not generally stated. For the most part, the differences in the vegetation are simply correlated with the differences in climate. Aitken (1922) for example made a detailed comparison of insolation, temperature ranges, and soil moisture of the north and south slopes of a hill near Maritzburg, and having found marked differences in climate, he correlated with them the differences in the vegetation. Similar observations were made on slopes X and Y, Fig. X, and similar results obtained (Figs. XI—XVI). We were curious to know, however, whether the effects of climate are direct or only indirect. We therefore set out to obtain evidence concerning this point, and have concluded that, in the area under discussion, the effect of the climate in the limitation of bush to south-facing slopes is indirect. The following observations were responsible for this conclusion :

1. On the farm Wildealskloof (*vide* Map 1) there is a koppie with bush developed on three sides—north-west, north, and east.

2. On the summit of a bult on Bayswater there is a small, completely isolated ring of bush (*vide* Plate 13A) developed in the collapsed walls of an old military sconce.

3. On the top of a bult on Hillside there is another small, isolated clump of bush. (Plate 13B.)

It was obvious, then, that the climate could not be the factor directly responsible for the absence of bush on bults, and on the slopes of koppies which face north or west, or bush would not have been able to develop on the above stations. It remained then to discover the factor directly governing the distribution of koppie bush. With this object in view the soils of south-facing slopes were compared with those of other slopes. Considerable difference was found to exist. The soil of the former is a "rough" talus giving the impression of considerable depth ; large irregular boulders and rocks jut out at different angles and the interspaces are filled with dark humous soil. Soil-filled rock-clefts several feet in depth are often visible. The soil of slopes facing north and west, on the other hand, though also talus, is more uniform ; the boulders are smaller, more regular, and usually somewhat rounded ; the actual soil-cover itself is more uniform and appears to be quite shallow.* Further investigation has shown that wherever koppie bush occurs, whether on northern or western slopes, as in observation 1, or whether in small patches on eastern slopes, or in its usual position on southern slopes, it invariably inhabits deep talus of the type described above. The question now arises whether it is the type of soil which is responsible for the development of the bush, or whether the presence of bush is responsible for the development of the soil type. Investigation of the soil conditions in observations 2 and 3 above, supports the former alternative. In 2 the broken-down sconce-walls have collected drift-sand, and in this way a deep talus-like soil has been built up. In 3 the same effect has been obtained from blasting† of the surface rock, and accumulation of drift-sand by the resulting rubble. The above two observations are of the nature of actual experiment, and in both cases it is quite obvious that it is the soil type which is responsible for the development of bush on these stations, and not *vice versa*.

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* We regret that actual figures of depth cannot be given as the measurement o talus soils involves considerable labour.

† Some time in the past blasting for the purpose of obtaining road-metal was commenced on this site, but for some reason the spot was abandoned and a quarry cut a short distance west of it.

Having concluded that it is the *edaphic* factor which directly controls the distribution of koppie bush, a further consideration comes to mind, namely, that of drainage and seepage, but as the whole Area is composed of an unstratified doleritic boss, this consideration does not obtain.

Figs. XI—XVI show clearly the disparity between the climates of slopes facing south and of those facing north. Yet the fact that koppie bush occasionally occurs elsewhere than on slopes with a southerly aspect shows that factors other than the direct action of climate on the vegetation are operative. Climate is probably of great importance indirectly in determining the depth and type of soil produced on different slopes and, regarding this, Professor W. von Bonde has given the following explanation of the presence of a deep rubble-soil on the southern slopes of koppies : " All accumulations are due in the first instance primarily to frost action and insolation. The lesser depths of the talus on north slopes as compared with south slopes are due to the more rapid removal of the products of weathering from north slopes by torrential rains which almost invariably fall from N.E., N. or N.W. before strong driving winds. The northern 'runs off' is therefore rapid and little 'sinking in' occurs. On the southern slopes, on the other hand, the 'run off' is less and hence the 'sinking in' is more gradual ; hence there is a greater tendency for chemical action to produce soil. The constant accumulation therefore of rock-rubble due to frost action and insolation together with chemically produced soil gives the southern slopes of koppies a greater amount of rubble-soil accumulation than is found on the northern slopes.

It must also be borne in mind that the 'towards the sun' aspect of the northern slopes favours a drying out action by the sun, whereas the southern slopes turned away from the sun tend to retain their moisture for a longer period, therefore favouring chemical decomposition of rock-rubble. Hence it is obvious that :—

(1) Southern slopes have a deep dominantly chemically-produced soil of fair humidity content.

(2) Northern slopes have a shallow dominantly physically-produced soil of low humidity content."

It seems therefore that the usual restriction of Koppie Bush to slopes facing south or south-east is due to climate, and that this factor acts indirectly by determining the character of the soil. But the direct action of climate on the vegetation must govern the luxuriance of the Bush.

Plate 13B shows that by creating a deeper talus it is possible to cause stands of bush to develop where bush does not normally occur. Could this idea be applied on a small scale in planting patches of trees in the extensive treeless areas of the Orange Free State? Blasting which has been used to open up rocky ground in preparation for tree planting no doubt acts by enabling air and water to penetrate deeply, and must in time result in the production of a deep layer of chemically-produced soil.

Spruit-bank-valley bush.

The factor concerned in the distribution of this association is moisture which is itself dependent upon the depth of soil and topographical position of the habitat. The valleys with their spruits receive, as run-off and drainage, a large part of the rain falling upon the adjacent slopes, and are consequently, by comparison with other habitats, relatively moist. Below is a table showing the averages of a number of moisture-content determinations made in different associations. The samples were taken at a depth of two inches, two days after a rainfall of 0·5 inch.

TABLE III.

Comparison of the soil-moisture contents, at 2 inches depth, in different associations after a rainfall of 0·5 inch.

Mesembryanthemum spinosum—Euphorbia mauritanica	4·35%
Euryops sulcatus—Euphorbia mauritanica	4·97%
Euryops sulcatus—Themeda triandra	10·24%
Koppie scrub	6·82%
Rhus ciliata—Themeda triandra	8·63%
Koppie bush	12·98%
Spruit-bank-valley bush	13·44%
Acacia bush	13·89%
Valley grassland	wet

As mentioned earlier in this paper, the soil of spruit-bank-valley bush may reach depths of over 25 feet. Although the surface shows an acid reaction, a true picture of the soil is obtained only by an examination of its profile. A section of the wall of a spruit 10 feet in depth comprised 4 distinct horizons as regards reaction. The first, 12 inches thick, slightly acid; the second, 18 inches thick, neutral; the third, 4 feet thick, strongly alkaline; the fourth zone, 3½ feet thick, neutral in reaction. The acidity of the first horizon is probably due to the leaching out of the soluble salts, which accumulating in the third horizon form a type of podsol. Roots occur throughout all these horizons.

Acacia bush.

Towards the mouths of the valleys where the gradient is considerably reduced the spruits form flushes as described by Bews (1916). The rate of flow of water is checked causing deposition of suspended matter. Soils up to 4·0 feet deep have been formed and these are usually more moist than those higher up the valleys (*vide* Table 7). *Acacia* bush follows the flushes.

Bews (1925), and Galpin (1926) have made the observation that *Acacias* are usually found on soil rich in lime, but down to a depth of 3 feet this soil continued to show an acid reaction.

Acacia bush shows signs of being displaced by spruit-bank-valley bush although normally one would expect the succession to be the reverse of this. Seedlings and saplings of *Celtis rhamnifolia* are numerous, while thriving young plants of *Royena decidua*, *Rhus lancea*, *Zizyphus mucronata* and *Rhus pyroides* are also found. Large trees, however, of the above species are rare. We may assume, therefore, that in recent years some change has taken place in the association allowing the entrance of spruit-bank-valley bush species. The cause of this is not yet known. Young trees and seedlings of *Acacia karroo* are scarce. This may be partly due to the fact that when the trees flower in summer the inflorescences and young pods become heavily infested with the rust-fungus *Ravenalia MacOwaniana* which causes gall-like growths, inhibiting seed production.

A large percentage of the older trees of *Acacia karroo* are severely attacked by a borer-grub, the larva of *Macrotoma palmata Fbr.*, and where an old tree has died, in the clearing produced, a dense stand of young individuals of the spruit-bank-valley bush association is found.

Valley grassland.

From what has been said concerning its habitat, it will be realised that moisture and depth of soil are the factors concerned in the distribution of valley grassland. Though generally luxuriant, the richness in species of any particular stand is dependent upon the water supply of the soil. From its distribution it will be realised that although the association always inhabits relatively moist situations, the degree of moisture varies from stand to stand. The flushes are more moist than the watercourses, and in a single flush even, variations in moisture are considerable. Figs. VIII and IX show the zonation of species in two flushes, the soil becoming progressively drier from the centre outwards. Thus the flushes are richer in species than are the somewhat drier watercourses. In the flushes the more hygrophytic species, including *Eragrostis nebulosa*, *Panicum minus var. planifolium*, *Pennisetum sphacelatum*, *Diplachne fusca*, are most in evidence. Along the watercourses *Themeda triandra*, *Digitaria eriantha* and a few others predominate, while a scattering of the above species is also usually present.

Fire.

During the past twenty years at least fire has had very little effect on the vegetation of the Area. This is to be ascribed partly to heavy grazing, partly to the open character of most of the vegetation and partly to the fact that the few bush and grass communities that are relatively dense occur in small patches.

Soil the Controlling Factor.

The climate, geology, and topography have co-operated in the production of a number of varied and relatively stable soil types, and it is these which determine the distribution of the associations. Soil-depth particularly, with its increase or decrease in water-content, is the important factor. The direct effect of topography on soil-moisture must not be overlooked, however, as those soils most favoured as regards depth are also (with the exception of the soil of koppie bush) the soils most favourably placed with regard to water supply ; the deep alluvial soils of the valleys and depressions receive a large portion of the rain which falls upon the slopes.

(*e*) THE SUCCESSION.

There are two distinct lines of succession followed in the area investigated :

(1) Commencing on bare rock surfaces (*lithosere*).
(2) Commencing in water (*hydrosere*).

Of the first line of succession there are two types, dependent upon aspect : (i) the moist type which proceeds on slopes of koppies and dongas facing south and south-east ; and (ii) the dry type on slopes facing north and west.

(1) *Lithosere.*

(i) Moist type. On the faces (chiefly southern) of rocks on donga-sides and koppie-slopes facing south, the first plants to gain foothold are unicellular *Cyanophyceae*. Following, or entering at the same time as these are a number of colonies of small crustaceous lichens. These pioneers disintegrate the rock in patches, producing a rough, mottled surface. At this stage several mosses, notably *Ptychomitrium cucullatifolium*, *Tortula pilifera* and *Bryum mundii* are able to secure a footing. Of these the xerophytic *Ptychomitrium* is the most significant. It forms mats ½ to 1 inch thick on the shady sides of rocks. Its lower parts, which die off, collect wind-blown sand, and silt, and in this way a thin layer of humous soil is held in position on the rock-face. In the moss mats, now become established the ferns *Cheilanthes hirta* and *Ceterach cordatum*. At this stage in the succession, splitting of the rock is generally found to take place. The first plants to enter the crevices are liverworts, *Riccia albomarginata* and *Trichostomum brachystomum* chiefly. They form fairly extensive mats and bind any sand or debris which may have collected in the chinks of the rocks. As the crevices become widened, chasmophytic ferns (*Notholaena Eckloniana*, *Cheilanthes hirta*, *Pellaea hastata*) and grasses (*Eustachys paspaloides*, *Rhynchelytrum roseum*, and several others), invade the liverwort mats and assist in thes oil-building process. Other chomophytes (rock-detritus plants) now enter. These are, *Sarcostemma viminale*, *Phyllanthus maderaspatensis*, *Indigofera Zeyheri*, *Kleinia radicans*, *Anacampseros filamentosa*, *A. telephiastrum*, *Cotyledon trigyna*, *Crassula platyphylla*, *Euphorbia aspericaulis*, and *E. caterviflora*. *Euryops multifidus*, and several other shrubs now make their appearance. The rocks, after being further prized apart, and after sufficient soil has collected in the interspaces, will present a sub-stratum of talus type suitable for bush colonisation.

(ii) Dry type. The dry type of the lithoseric succession differs from the moist type in not having either the moss or the liverwort stages represented ; the ferns *Ceterach cordatum* and *Cheilanthes hirta*, important members of the moist type, do not find a place in the succession, while the chasmophytes *Sarcostemma viminale*, *Kleinia radicans* and *Phyllanthus maderaspatensis* are rare in it. If the succession is proceeding on the bults, the shrubs *Euryops sulcatus*, *Eriocephalus spinescens* and *Mesembryanthemum spinosum* enter upon the chasmophytic stage, and if proceeding on the koppies, *Euryops multifidus*, *Euclea ovata* and other scrub species also settle in. The succession has now reached its climax except for one late arrival, *Euphorbia mauritanica*, which develops in the protection of the above shrubs. It usually displaces *Eriocephalus*, but although it generally grows taller than either *Mesembryanthemum* or *Euryops* it is seldom able to displace them, but kills by shading those portions of the plants which it surrounds.

Small areas of gravel, ½ to 1½ inches in depth, collect about the margins and in depressions of rock outcrops on the bults. The earliest colonists of these gravel patches are the cushion plant *Stomatium mustellinum* and the small tufted grass *Lepturella capensis* (Plate 7B); others are *Ruschia unidens*, *Anacampseros ustulata* and occasionally *A. filamentosa*. After these plants have assisted further in the weathering of the gravel, the patches become invaded and closely colonised by the grasses *Eragrostis denudata*, *Tragus koelerioides* and species of *Aristida*.

(2) *Hydrosere.*

The succession, as pieced together from a study of small ponds of standing water in the flushes, is as follows: Species of the green alga *Spirogyra* are the first to make their appearance. They form large blankets on the surface of the water and are also found submerged, attached to stones and debris. When well developed, the algae may almost fill the pond. Various aquatics now make their appearance. These are banded into zones:

(i) Fairly deep water, 1-3 feet. Here are found two types:
  A. Submerged and rooted (*Chara spp.*).
  B. Rooted, with submerged leaves and aerial inflorescences (*Lagarosiphon muscoides*, *Potamogeton pusillum*).

(ii) Shallow water, 4-12 inches. Again two types are represented:
  A. Rooted in soil with floating leaves (*Marsilea macrocarpa*) and with free aerial inflorescences (*Limosella aquatica var. tenuifolia*).
  B. Rooted in soil with free aerial leaves and inflorescences (*Polygonum lapathifolium* and the sedges *Scirpus spp.*, *Cyperus spp.* and *Mariscus spp.*).

(iii) Wet soil around the margins of ponds is inhabited by a number of *Cyperaceae* and the grasses *Eragrostis nebulosa*, *Panicum minus var. planifolium*, *Pennisetum sphacelatum* and *Diplachne fusca* chiefly (*vide* Fig. VIII). Passing outwards into drier soil these are replaced by mesophytic, and in fact, somewhat xerophytic species (*Themeda triandra*, *Digitaria eriantha*, *Sporobolus fimbriatus* and others).

Succession in Grassland.

Protection from grazing could not be arranged in the Area but the Council of the University College of the O.F.S. very willingly set aside for Pasture Research and fenced off a number of small grass camps in the College grounds. Twelve quadrats were laid down and were charted in March, 1934, and again in March, 1935. It was hoped that by the selection of a series of plots in successive stages of development along the anticipated line of succession, the course of the succession might be confirmed in a single growing season. In this respect the results were disappointing, but arrangements have been made to continue the quadrats for several years.

During the twelve months only one quadrat showed an appreciable degree of progressive succession : *Themeda* advanced at the expense of *Digitaria*, both in number and size of the tussocks, resulting in an increase of the grass-cover. Another showed the colonisation of a bare area by but two individuals (of the annual, *Tragus racemosus*). In most of the other quadrats there was a complete or partial loss of annuals (grass and others) which was not compensated for by the increase in size of the surviving perennials so that the net result was a decrease in the vegetable cover.

The disappointing results are to be attributed to the season which was unfavourable to the growth of grass, for although 19·68 inches of rain were recorded for the period October 1st, 1934, to March 31st, 1935, only 3·79 inches were recorded during the period December 22nd, 1934, to March 20th, 1935. Thus the best part of the growing season was practically rainless. The dryness of the season was further aggravated by a succession of hot desiccating winds following upon precipitation.

A study of the reaction of the vegetation to various disturbances as found in the cultivated and otherwise disturbed parts of the Area was also begun. Here again, to ensure protection from grazing, plots were laid down in the grounds of the University College. As yet there is nothing to report.

(*f*) SEASONAL ASPECTS.

There are five more or less well-defined flowering aspects : hibernal, prevernal, vernal, aestival and autumnal. In the case of some of the plants named, especially the geophytes there is a general flowering as a rule only at intervals of several years.

1. Hibernal (June-August). The period June-August is characterised by the flowering of *Aloe grandidentata*. Rocky slopes and koppie summits are mottled with colour : the flame-coloured flower-clusters of the *Aloe* show up brightly against a background of bleached grass tussocks. *Rhus lancea* blooms at this time too, but its flowers are inconspicuous.

2. Prevernal (August-September). During this period, before the termination of frosts, *Euryops multifidus* and *Euphorbia mauritanica* come into flower. The latter is especially prominent, its yellow inflores-

cences co-mingling with the pink of the aloe rearguard do much towards brightening the view. To this is added, in late September, a mauve hue by *Mesembryanthemum spinosum* so that the bults and koppies become at this period distinctly colourful. At this time, too, are found groups of the mauve-flowered shrub, *Aster fruticulosa*, blooming profusely, while *Pachypodium succulentum*, *Pterodiscus speciosus* and *Chrysocoma tenuifolia* add a further sprinkling of colour. The prevernal is the brightest and best defined of the flowering aspects.

3. Vernal (September-November). With the rise of temperatures in spring the deciduous trees don their foliage and commence flowering, but with the exception of *Grewia occidentalis*, *Royena decidua* and *R. microphylla*, the flowers are inconspicuous. Provided the season is not too dry, *Chilianthus arboreus* makes a very brave show of creamy-white against the south-facing slopes of koppies, while the flushes are transformed into bright gold by the flowering of *Acacia karroo*. In grassland areas numerous herbaceous plants such as *helichrysums*, *lobelias*, *asclepiads*, *sebaeas* and many others come into flower while *homerias* and *moraeas* are also in evidence. In rocky ground the geophytes, *Ammocharis falcata*, *Bulbine spp.*, *Haemanthus hirsutus*, *Buphane toxicaria*, *Hypoxis spp.*, add colour to the season ; rocky watercourses are made quite showy by the numerous flowers of *Tulbaghia acutiloba* and *Dipcadi spp.* ; *Sesamum capense* exhibits its mauve flowers in varied habitats ; and scattered shrubs of the orange-flowered *Hermannia Rehmannii* are not inconspicuous at this season. When in flower, the drie doorn (*Rhigozum obovatum*) with its golden yellow flowers, which usually appear in October and November, is probably the showiest of the wild shrubs growing near Bloemfontein, but like so many other members of the native flora it does not flower profusely every year. Being somewhat rare here it is little known.

4. Aestival (November-March). Summer is not rich in conspicuous flowers. A large number of small herbaceous plants in flower are scattered through the Area. *Euryops sulcatus* blooms sporadically after every shower of rain. The grasses generally flower during this period (provided sufficient rain has fallen) ; the pink, feathery inflorescences of *Rhynchelytrum roseum* are conspicuous especially on bult and koppie summit. Dotted about the Area are seen in flower *Nerine sp. nr. lucida*, *Cotyledon decussata*, *Kalanchoe paniculata*, *Anacampseros spp.*, *Clematis Thunbergii* (along spruits), *Stomatium mustellinum*, *Ruschia unidens* and other *Mesembryeae*. In late summer the reddish-pink flower-heads of *Brunsvigia grandiflora* are met with, while *Sarcostemma viminale* blooms profusely on bult and koppie. On the whole, however, the summer season is not colourful.

5. Autumnal (March-May). Autumn is characterised chiefly by *Nidorella hirta* which converts disturbed grasslands, and fallow lands into seas of bright yellow, and by *Euryops multifidus* which again comes into flower and imparts a yellow hue to koppie slopes. The *Stapelieae* are now in full bloom ; *Selago albida* is fairly prominent, while the small mauve-pink flowers of *Cyphia triphylla* are sprinkled through the grasses on the slopes of bults. *Hessea karooica*, also, is fairly abundant in rocky situations.

(*g*) RAUNKIAER'S LIFE FORM SPECTRUM.

In Table 4 are given the life-form spectrum of the flora of the Area, the spectrum of each association, and the normal spectrum. The percentage figure for each form is expressed to the nearest unit.

From the description of the climate, given earlier in this paper, we would have expected, perhaps, to find higher values of H and G in the spectrum of the Area. The high figure for therophytes, however, is in accordance with what we would expect, and this figure would be still higher were all the ruderals and weeds of cultivated portions included.

TABLE IV

RAUNKIAER'S LIFE-FORM SPECTRUM.

	No. of Species.	S	E	MM	M	N	Ch.	H	G	HH	Th
Normal Spectrum ..	400	1	3	6	17	20	9	27	3	1	13
Spectrum of the Area ..	374	3	..	..	5	9	22	10	12	5	34
Mesembryanthemum spinosum--Euphorbia mauritanica.	46	11	..	..	..	7	30	28	17	..	7
Euryops sulcatus — Euphorbia mauritanica ..	50	6	..	..	..	4	32	34	14	..	10
Euryops sulcatus—Themeda triandra ..	55	6	..	..	..	4	16	33	16	..	26
Koppie scrub	79	13	..	..	14	10	13	30	10	..	10
Rhus ciliata — Themeda triandra	40	5	..	..	..	3	13	35	8	..	37
Koppie bush	38	8	..	..	21	8	13	21	13	..	16
Spruit-bank-valley bush	30	..	..	3	23	10	17	20	3	..	24
Acacia bush	20	..	..	5	25	15	..	15	10	..	30
Valley grassland ..	60	..	..	..	..	..	..	35	15	30	20

The relatively high (compared with the figure in the normal spectrum) value for HH may occasion some surprise, but, from what has gone before, it will be realised that it is the topography of the Area, rather than the climate, which is responsible for this.

A similar criticism to that embodied in a reply by Raunkiaer (1934, p. 190) to Warming's observations regarding the Brazilian Campos may be levelled against this treatment of the subject since the climate of the Bloemfontein district—and one might include the whole of the central portion of the Orange Free State—is more or less uniform, the spectrum, to give a reliable picture of the plant climate, must be calculated from all the species of the whole area instead of from one very small part of it. It would seem then that we must first, by meteorological methods, determine the climatic limits of an area or region before we attempt to work out the spectrum for it. The fact remains, however, as Warming has indicated, that within a given region having a uniform climate, although the spectrum worked out for the region as a whole may afford a reliable picture of the climate, local variations in topography and soil do affect the spectrum. It is obvious that the water-relations of the soil are not entirely conditioned by such factors as precipitation, humidity, winds, but to a large extent, also, by the nature of the substratum itself.

As seen in the table, we have attempted a comparison of the spectra of the various plant associations but the numbers of species are so greatly reduced in this treatment that the values for the different forms tend to be misleading, and comparison between associations break down. If, for example, the two associations spruit-bank-valley bush, and Acacia bush are compared, the former is found to show a lower value for MM than the latter, whereas in actual fact it is but a single species, *Celtis rhamnifolia*, which is concerned in both.

(*h*) THE RELATIONSHIP OF THE AREA TO THE KARROO.

As mentioned in the introduction, the Area bears resemblances to the Karroo. The description of its physical and vegetational features will, it is hoped, have made this clear to the reader who is familiar with the Karroo. Pole Evans (1920, 1929) aptly describes the latter as a country of dry river-beds, shallow soils and exposed rock surfaces. The vegetation is scanty and consists of isolated tufts of bunch-grasses, stunted bushes and shrublets and is dominated over large areas, in the western portion, by *Euphorbia mauritanica* and, in the central portion, chiefly by *Mesembryanthemum spinosum*. The small patches of stunted bush found in the Karroo are similar to those in the Area, which has approximately 60 species of plants in common with the Karroo, but differs from it, in having a greater grass population.

The occurrence of a Karroid type of vegetation well within a great grassveld region arouses interest ; it demonstrates the development of a similar type of vegetation as a result of similar conditions, and raises the question of its origin. Bews' (1925) view of the evolution of the S. African flora would dispose of the possibility of the Area representing a surviving remnant of a greater Karroo which in earlier times extended much further north than it does to-day, while the presence of identical, characteristic species precludes the hypothesis of purely parallel evolution. It is interesting to note, however, that a species such as *Mesembryanthemum spinosum*, which is apparently unable to survive in grassveld, must have migrated a distance of over 100 miles across a barrier of grassveld in order to have become established in the Bloemfontein Area.

(*i*) THE FLORA OF THE AREA.

The list of plants tabulated below is, in all probability, far from being complete, but it serves, nevertheless, as a fairly good working basis. The weed population of cultivated land is not included ; neither are the algal or fungal populations listed, as knowledge of these is very incomplete. Introduced weeds which have become naturalized are included and are marked with an asterisk. Specimens of the species listed are preserved in the University College Herbarium.

BRYOPHYTA.

HEPATICAE.

Anthoceros laevis. Linn.
Fossombronia pusilla. (L) Dum.
Fimbriaria marginata. Nees.
Grimaldia sp.
Plagiochasma rupestre. Steph.
Riccia limbata. Besch.
R. albomarginata. Besch.
R. Pottsiana. Sim.
Targionia hypophylla. Linn.
Trichostomum brachystomum.

MUSCI.

Bryum turbinatum. (Hedw.) Schw.
B. canariense. Schp.
B. stellipilum. C.M.
B. mundii. C.M.
Dicranella sub-compressa. Hampe.
Didymodon afer. C.M.
Entosthodon Bergianus. Br. and Sch.
E. ampliretis. C.M.
E. Rottleri. C.M.
Fabronia pilifera. Hornsch.
Fabronia sp.
Fissidens bryoides. L.
F. pycnophyllus. C.M.
Hymenostylium ceratodonteum. Broth.
Hyophila Zeyheri. Jacq.
Physcomitrium succulentum. W. and W.
Pseudoleskeopsis claviramea. Jaeg.
Ptychomitrium cucullatifolium. C.M.
Tortula pilifera. Hk.
T. atroviridis. Lindb.
Weisia calcarea. C.M.
W. hyophiloides. W. and B.

PTERIDOPHYTA.

Marsileaceae.

Marsilea macrocarpa var. capensis. Sim.

Polypodiaceae.

Ceterach cordatum. (Thb.) Des.
Cheilanthes hirta. S.W.
Notholaena Eckloniana. Kunzl. (resurrection fern).
Pellaea hastata. Pr. (oak-leaf fern).
Pellaea viridis. Prantl.

ANGIOSPERMAE.

DICOTYLEDONEAE.

Aizoaceae.

Chasmatophyllum musculinum. Schwantes.
Delosperma Pottsii. Bolus.
Hymenocyclus luteus. Schwantes.
Hypertelis verrucosus. Fenzl.
Mesembryanthemum scapigerum. Harv.
M. spinosum. Linn. (doringvygie).
Ruschia unidens Schwantes.
Trichodiadema barbatum. Schwantes.
Stomatium mustellinum. Schwantes. (kussingvygie).

Amarantaceae.

*Alternanthera echinata. Smith (kakiekweek).
*Amaranthus paniculatus. Linn. (kalkoenslurp).
*A. Thunbergii. Moq. (Cape pigweed, red devil, mistbredie).
*A. caudatus. Linn.
*A. Blitum. Linn.
Achyranthes aspera. Linn. (klits, haakensteek).

Anacardiaceae.

Rhus Burchellii. Sond.
R. ciliata. Licht. (kriebessie).
R. erosa. Thunb. (besembos, soettaaibos)
R. lancea, Lf. (kareeboom).
R. pyroides. Burch. (taaibos).

Apocynaceae.

Pachypodium succulentum. A.D.C. (dikvoet).

Araliaceae.

Cussonia paniculata. E. and Z. (cabbage tree, cork tree ; kiepersol, sambreel, nooiensboom).

Asclepiadaceae.

Asclepias multicaulis, Schltr. (melkbos, gansies).
A. fruticosa. Linn. (wilde kapok, tondel).
A. Burchellii. Schltr.
A. brevicuspis. Schltr.
A. gibba. Schltr.
A. Meyeriana. Schltr.
Caralluma lutea. N.E.Br.
Duvalia corderoyi. N.E.Br. (Hotnotstoontjie).
Sarcostemma viminale. R.Br. (melktou).
Stapelia flavirostris. N.E.Br. (carrion flower ; bokhoring, aasblom).
S. gemmiflora. Mass. (carrion flower ; bokhoring, aasblom).

Bignoniaceae.

Rhigozum obovatum. Burch. (driedoring).

Boraginaceae.

Anchusa capensis. Thb. (forget-me-not ; ossetong).
Echinospermum lappula. Lehm.
Ehretia rigida (hottentotica). Burch. (Cape lilac).
Tournefortia tuberculosa. Cham.

Campanulaceae.

Cyphia triphylla. Phill.
Lightfootia albens. Spreng.
Lobelia Tysoni. Phillips.
Laurentia arabidea. A.D.C.
Parastranthus thermalis. Sond.
Wahlenbergia arenaria. A.D.C. (harebell).
W. nudicaulis. A.D.C.

Caryophyllaceae.

Dianthus scaber. Thb. (wild pink ; wildeangelier).
Pollichia campestris. Ait. (kaffer-druiwe)
*Stellaria media. Cyrill. (chickweed ; sterremuur).
Silene capensis. Benth.

Celastraceae.

Gymnosporia polyacantha. Szyszy.

Chenopodiaceae.

*Chenopodium ambrosioides. Linn. (stinking goosefoot, Mexican tea ; stinkbossie).
*C. mucronatum. Thb.
*C. murale. Linn. (goosefoot ; gansevoet)
Salsola foetida. Del.

Compositae.

Amphidoxa gnaphaloides. D.C.
Arctotis stoechadifolia. Berg. (bear's ears).
Artemisia afra. Jacq. (wormwood ; wildeals).
Aster fruticulosus. Less.
A. filifolius. Vent. (draaibossie, gombossie).
A. muricatus. Less.
Bidens pilosa. Linn. (black-jack ; wewenaars).
Cenia microglossa. D.C.
Chrysocoma peduncularis. D.C. (bitter karobos).
C. tenuifolia. Berg. (bitter-bossie).
Cineraria geraniifolia. D.C.
Conyza podocephala. D.C.
Cotula leptalea. D.C.
Dicoma anomala. Sond. (wurmbos).
Euryops multifidus. D.C. (resin-bush ; geelmagriet, harpuisbos).
E. sulcatus. Harv. (resin-bush ; geelmagriet, harpuisbos).
Eriocephalus spinescens. Burch. (silwerbossie).
Felicia muricata var. fasciculata. E.Mey.
F. fascicularis. D.C. (skaapbossie).
Garuleum pinnatifidum. D.C.
Geigeria passerinoides. Harv. (vermeerbossie).
Gnaphalium luteoalbum. Linn. (cudweed ; roerkruid).
Othonna pallens. D.C. (springbokbossie).
Helichrysum argyrosphaerum. D.C.
H. aureonitens. Sch. and Bep.
H. dregeanum. Sond. and Harv.
Ifloga paronychioides. D.C.
Kleinia longiflora. D.C.
K. radicans. D.C. (bokbos).
Lasiopogon lanatum. Cass.
Matricaria globifera. Fenzl. (stinkkruid).
Nidorella hirta. D.C.
Pentzia sphaerocephala. D.C.
P. virgata. Less. (goedkaro, skaapbos).
Senecio achillaefolia. D.C.
S. erosus. Lf.

S. glanduloso-pilosus. Volkens and Muschl.

S. laevigatus. Thb.

S. nudiusculus. D.C.

*Schkuhria bonariensis. Hook and Arn. (yellow tumble-weed; rolkakie, rolbossie).

Sonchus oleraceus. Linn. (sow-thistle ; melkdissel, sydissel).

*Tagetes minuta. Linn. (Mexican marigold).

Tarchonanthus camphoratus. Linn. (sagewood ; kamferhout).

T. minor. Less. (vaalbos).

Tripteris pachypteris. Harv.

Vernonia Kraussii. Sch. Bip.

Venidium microcephalum. D.C.

V. arctotoides. Less.

*Xanthium spinosum. Linn. (burweed ; boetebossie).

Convolvulaceae.

Convolvulus ulosepalus. Hall.

Ipomoea argyreioides. Choisy.

I. crassipes. Hook.

I. oblongata. E.Mey.

I. quinquefolia. Hochst.

Crassulaceae.

Cotyledoa. decussata. Sims.

C. trigyna Burch.

Crassula empestris. E. and Z.

C. Cooperi var. robusta. Schon.

C. corallina. Thunb.

C. fruticulosa. Linn.

C. muscosa. Linn.

C. nodulosa. Schon.

C. platyphylla. Harv.

Kalanchoe paniculata. Harv.

Cruciferae.

Heliophila suavissima. Burch.

Nasturtium fluviatile. E.Mey.

Sisymbrium lyratum. Burm.

Dipsacaceae.

Scabiosa columbaria. Linn. (wild scabious, pincushion, rice-flower).

Ebenaceae.

Euclea lanceolata. E.Mey. (bosgwarrie).

E. ovata. Burch. (gwarrie).

Royena (pallens. Thunb.) decidua. Burch. (bloubos).

R. (hirsuta. Linn) microphylla. Burch. (kritikom).

Euphorbiaceae.

Cluytia pulchella. Linn.

Euphorbia aspericaulis. Pax.

E. basutica. Marl. (vingerpol).

E. caterviflora. N.E.Br.

*E. Helioscopia. Linn. (milkweed, spurge ; melkgras).

E. mauritanica. Linn. (geel melkbos).

E. Rudolfi. N.E.Br.

Phyllanthus humilis. Pax.

P. maderaspatensis. Linn.

Gentianaceae.

Sebaea Conrathii. Schinz.

S. pentandra. E.Mey.

Geraniaceae.

Geranium incanum. Burm.

Monsonia biflora. D.C. (dysentery-herb ; naaldebossie, vrouebossie).

Pelargonium fumarioides. L.Her.

P. reniforme. Ait. (roderabas).

Labiatae.

Salvia rugosa. Thunb. (dassiebos, jakobjong).

S. runcinata. Linn.

S. clandestina. Linn.

Stachys hyssopoides. Burch.

Stachys spathulata. Burch.

Teucrium capense. Thunb. (paddaklou).

Leguminosae.

Acacia karroo. Hayne. (karodoring, soetdoring, witdoring, doringboom).

Dolichos gibbosus. Thb. (wilde-entjie).

Elephantorhiza Burchellii. Benth. (elandsboontjie).

Indigofera argyraea. E. and Z.

I. alternans, D.C.

I. cryptantha. Benth.

I. Zeyheri. Spreng. (leehout).

Lessertia annularis. Burch. (krimpsiektebos).

L. tenuifolia. E.Mey.

Listia heterophylla. E.Mey. (yellow clover, Cape hop).

Lotononis divaricata. Benth.

L. laxa. E. and Z.

Medicago denticulata. Willd. (klawergras, klitsklawer).

M. nigra. Willd. (bur-clover, little burweed).

*Melilotus parviflora, Desf. (melilot; stinkklawer).

Melolobium cernuum. E. and Z. (heuningbos).

M. candicans. E. and Z. (heuningbos).

Rhynchosia Totta. D.C.

Sutherlandia frutescens. R.Br. (cancerbush; kankerbos, eendjies, gansies).

Tephrosia lurida. Sond.

T. polystachya. E.Mey.

Trifolium africanum. Ser. (Cape clover).

*Vicia sativa. Linn.

Loganiaceae.

Chilianthus arboreus. Benth. (bastard olive; vaalbos, wildevlier).

Loranthaceae.

Viscum pauciflorum. Linn. (mistletoe; voëlent).

Lythraceae.

Lythrum hyssopifolium. Linn.

Malvaceae.

Abutilon Sonneratianum. Cor.

Hibiscus aethiopicus. Linn.

H. atromarginatus. E. and Z.

H. malacospermus. E.Mey.

H. pusillus. Thunb.

H. trionum. Linn. (Black-eyed Susan).

Sida cordifolia. Linn.

Martyniaceae.

*Martynia montevidensis. Cham. (mule-grab).

Nyctaginaceae.

Boerhaavia pentandra. Burch.

Oleaceae.

Menodora africana. Hook.

Olea verrucosa. Link. (wild olive; oleenhout, olyfboom, wilde-olyf, oliewenhout).

Oxalidaceae.

Oxalis corniculata. Linn. (sorrel; suuring, pypklawer.)

Papaveraceae.

*Argemone mexicana. Linn. (Mexican poppy; blouduiwel, steekbossie).

Papaver aculeatum, Thunb.

*Fumaria officinalis. Linn.

Pedaliaceae.

Pterodiscus speciosus. Hook.

Sesamum capense. Burm.

Phytolaccaceae.

Limeum linifolium. Fenzl.

L. viscosum. Fenzl.

Plantaginaceae.

Plantago dregeana. Pres.

Polygonaceae.

*Polygonum aviculare. Linn. (knotweed; duisendknoop, varkgras).

P. lapathifolium. Bolus.

Rumex Ecklonianus. Meisn. (dock).

Portulacaceae.

Anacampseros filamentosa. Sims. (hasieskos, moerplantjie).

A. telephiastrum. D.C.

A. ustulata. E.Mey.

Portulaca oleracea. Linn. (purslane; varkkos, postelein).

Primulaceae.

Anagallis arvensis. Linn. (scarlet pimpernel, poor man's weatherglass; rooimuur).

Ranunculaceae.

Clematis Thunbergii. Steud. (traveller's joy; klimop).

Ranunculus pubescens. Thunb. (buttercup; botterblom, kankerblaar).

Rhamnaceae.

Zizyphus mucronata. Willd. (wag-'n-bietjie, blinkblaar).

Rubiaceae.

Galium capense. Thunb.

Hedyotis stricta. Sond.

Nenax microphylla. E. and Mey.

Santalaceae.

Osyris compressa. A.D.C. (bark-bush, Cape sumach; bergbas, jakkalspruim).

Thesium confine. Sond. (teringbos).

T. racemosum. Bernh.

Saxifragaceae.

Vahlia capensis. Thunb.

Scrophulariaceae.

Diclis petiolaris. Benth.
Dischisma ciliatum. Choisy.
Limosella capensis. Linn.
L. aquatica. Linn. var. tenuifolia. Hook.
Manulea Benthamiana. Hiern.
M. androsacea. E.Mey.
Peliostomum leucorrhizum. E.Mey.
Selago albida. Choisy. (water-finder; aarbossie).
Sutera aurantiaca. Hiern.
S. argentea. Hiern.
S. caerulea. Hiern.
S. crassicaulis. Hiern.
Veronica anagallis. Linn. (speedwell).
Zaluzianskya crocea. Schltr.

Solanaceae.

Lycium oxycladum. Miers.
L. Kraussii. Dunal.
Solanum incanum. Linn. (bitterappel).
S. nigrum. Linn. (deadly nightshade, black nightshade; nagskade, nastergal).
S. panduraeforme. E.Mey.
S. supinum. Dunal.

Sterculiaceae.

Hermannia bryonaefolia. Burch.
H. comosa. Burch.
H. depressa. N.E.Br.
H. pallens. E. and Z.
H. Rehmannii. Szyszy.
Mahernia coccocarpa. E. and Z.

Thymelaeaceae.

Gnidia polycephala. M.M. (Januariebossie).

Tiliaceae.

Grewia occidentalis. Linn. (four-corners; kruisbessie).

Ulmaceae.

Celtis rhamnifolia. Presl. (white stinkwood, Camdeboo stinkwood; witstinkhout, Camdeboostinkhout).

Umbelliferae.

Heteromorpha arborescens. C. and S. (bergbas).

Urticaceae.

*Urtica dioica. Linn. (nettle; brandnetel).

Verbenaceae.

Bouchea pinnatifida. Schauer.
Lantana salviaefolia. Jacq. (birds' brandy, num-num).
Lippia reptans. H.B. and K.
Verbena officinalis. Linn. (wild verbena; verfyn).

Zygophyllaceae.

Tribulus terrestris. Linn. (dubbeltjie, dubbeldoring, volstruisdoring, duiweltjie).

MONOCOTYLEDONEAE.

Amaryllidaceae.

Ammocharis falcata. Herb.
Brunsvigia grandiflora. Lind.
Buphane toxicaria. Herb. (seeroogblom, gifbol, kopseer).
Haemanthus hirsutus, Bkr. (Bible plant).
Hypoxis angustifolia. Lam.
H. argentea. Harv. var. sericea. Bkr. (sterretjie).
Nerine sp. nr. lucida.

Commelinaceae.

Commelina africana. Linn.
C. karrooica. C.B. Clark.
C. bengalensis. Linn.

Cyperaceae.

Bulbostylis humilis. Kunth.
Cyperus difformis. Linn.
C. bellus. Kunth.
C. longus. Linn.
C. marginatus. Thunb.
C. usitatus. Burch. (uintjie, watergras).
Kyllinga alba. Nees.
Mariscus capensis. Schrad. (monkey bulb; bobbejaansuintjie).
M. Rehmannianus, C.B.Cl.
Scirpus lacustris. Linn.
S. hystrix. Thunb.
S. Burkei. C.B.Cl.
S. nodosus. Rottb. (biesie).
S. paludicola, Kunth.
S. setaceus. Linn.

Gramineae.

Agrostis griquensis. Stapf.
Aristida angustata. Stapf. (steekgras).
A. Burkei. Stapf (steekgras).
A. barbicollis. Trin. and Rupr. (steekgras).
A. congesta. Roem and Schult. (steekgras).
Brachiaria Isachne. Stapf.
B. serrata. Stapf.
Briza minor. Linn.
Bromus unioloides H.B.K. (rescue grass).
Chloris virgata. Sw. (haygrass, sweetgrass ; klossiesgras, wilde hawer).
Cymbopogon plurinodis. Stapf.
Cynodon dactylon. Pers. (couch, quickgrass ; buffel-kweek, Batavisekweek).
C. incompletus. Nees (couchgrass ; fynkweek).
Digitaria eriantha. Steud. (fingergrass ; vingergras).
D. sanguinalis. (Linn.) Scop. (wild mllet).
D. ternata (Hochst.) Stapf.
Diplachne fusca. Beauv.
Ehrharta erecta. Lam.
Eleusine indica. Gaertn. (goose-grass, crowfoot).
Enneapogon scoparius. Stapf.
E. brachystachyus. Stapf.
Eragrostis chloromelas. Steud.
E. curvula. Nees. (blousaad).
E. denudata. Hack (skaapgras).
E. gummiflua. Nees.
E. Lehmanniana. Nees. (soet blousaad)
E. major. Host
E. margaritacea. Stapf.
E. micrantha. Hack.
E. nebulosa. Stapf.
E. obtusa. Munro.
E. plana. Nees. ab. E (ospolgras).
E. procumbens. Nees.
E. superba. Peyr.
Eustachys paspaloides. L.M.
Heteropogon contortus. L.Beauv. (speargrass ; steekgras).
Hemarthria fasciculata. Kunth.
Hyparrhenia hirta. Stapf.
Lepturella capensis. Stapf.
Lolium temulentum. Linn. (darnel ; drabok).
Microchloa caffra. Nees.
Panicum deustum. Stapf.
P. minus var. planifolium Stapf.
Paspalum dilatatum. Poir (large waterseed ; breedsaad).
Pennisetum sphacelatum (Nees) Dur. and Schinz.
Poa annua. Linn. (walkgrass).
Pogonarthria falcata. Rend.
Phalaris minor. Retz. (small canary grass).
Rhynchelytrum roseum. Stapf. and Hubb.
Schismus fasciculatus. Beauv. (haasgras).
Setaria aurea. A. Braun.
S. flabellata. Stapf.
S. imberbis. R. and S.
S. verticillata. Beauv. (klitsgras).
Sporobolus discosporus. Nees.
S. fimbriatus. Nees.
S. Ludwigii Hochst.
Themeda triandra. Forsk. (red grass ; rooigras).
Tragus koelerioides. Asch.
T. racemosus. All.
Trichoneura grandiglumis. Rendl.
Triraphis andropogonoides. (Steud) Phill.
Urochloa helopus. Stapf.

Hydrocharitaceae.

Lagarosiphon muscoides. Harv. (pondweed, watergrass ; barbelgras, watergras).

Iridaceae.

Gladiolus edulis. Burch. (small afrikander ; klein aandblom, patrysuintjie).
Homeria aurantiaca. Sweet. (red tulp ; rooitulp).
H. pallida. Baker.
Moraea polystachya. Ker. (bloutulp).
M. simulans. Baker.
M. tenuis. Ker.

Juncaceae.

Juncus exsertus. Buchen.
J. rupestris, Kunth. (rush ; biesie).

Liliaceae.

Albuca sp. (undetermined).

Aloe grandidentata. Salm-Dyck. (aloe; alwyn).

Androcymbium melanthioides. Willd. (men-in-a-boat; patrysblom, bobejaanskoen).

Anthericum campestre. Moss.

A. paniculatum. Moss.

A. trichophyllum. Moss.

Asparagus africanus. Lam. (wag-'n-bietjie).

A. angolensis. Baker.

A. asiaticus. Linn. (katbos).

A. microrhaphis. Baker.

Asparagus sp. (undetermined).

Bulbine asphodeloides. R. and S. (wilde kapiwa, geel katstert).

B. narcissifolia. Salm-Dyck (slangkop).

Dipcadi gracillimum. Baker.

D. hyacinthoides. Baker (curly-curly, jig-a-jig).

Drimia angustifolia. Baker.

Eriospermum Bellendeni. Sweet.

Eucomis undulata. Baker. (wild pineapple; krulkop).

Hessea karooica. Barker.

Massonia Greenii. Baker.

Ornithogalum setifolium. Kunth.

O. spicatum. Baker.

Scilla lanceaefolia. Baker. (wild squill).

S. MacOwani. Baker.

S. rigidifolia. Kunth. (wild squill).

Symplegma pulchellum (Baker) Moss.

Tulbaghia acutiloba. Harv. (wild garlic).

Potamogetonaceae.

Potamogeton pusillum. Linn. (pondweed; fonteinkruid).

SECTION IV.

SUMMARY.

SECTION I.

The site investigated is approximately 18 sq. miles in extent. It is situated to the north of the town of Bloemfontein and is composed of rocky koppies and bults separated by winding valleys through which wander dry spruits and sloots. The soils are mostly shallow and interspersed with exposed rock-surfaces. The Area gives the general impression of an island of scrub raised in a sea of grassveld. It is clothed mainly by short, open scrub in which are scattered small patches of bush and grassland

SECTION II.

(*a*) The climate is one of summer rains; it is characterised by droughts and great extremes of temperature. The summers are long and hot; hot desiccating winds are a feature. The winters are characterised by very low night temperatures accompanied by severe frost. Hail is frequent; snow is rare.

(*b*) The Area is composed of a doleritic boss overlying rock of the Beaufort Series. It has been weathered to form a network of valleys and dongas between which are the koppies and bults. The irregular and broken nature of the topography offers many and varied habitats to plants.

(*c*) The soils are mostly shallow; all are of doleritic origin, (1) sedentary, brown and gravelly, or (2) alluvial, dark-coloured and clayey. Those on bults, on north-east, north, and west slopes of koppies are of the first type; those in valleys and depressions are of the second type.

SECTION III.

(*a*) The vegetation is composed of three main types: scrub, bush and grassland. Scrub comprises the 5 associations; *Mesembryanthemum spinosum—Euphorbia mauritanica*; *Euryops sulcatus—Euphorbia mauritanica; Euryops sulcatus—Themeda triandra; koppie scrub;* and *Rhus ciliata—Themeda triandra.*

Bush includes 3: *koppie bush; spruit-bank-valley bush* and *Acacia bush.*

Pure grassland is composed of the single association, *valley grassland.*

Scrub occupies 92% of the total vegetation cover, bush 6% and grassland 2%.

(*b*) *Mesembryanthemum spinosum—Euphorbia mauritanica* inhabits the most rocky and shallow-soiled situations on bults and koppie summits.

Euryops sulcatus—Euphorbia mauritanica occupies somewhat deeper and less rocky soils on bults.

Euryops sulcatus—Themeda triandra finds its abode on still deeper soils, and is found both on brown soil on koppies and bults, and in dark alluvial soil in depressions.

Koppie scrub clothes the summits of koppies, and koppie-slopes facing north-east, north and west. The soil is shallow talus.

Rhus ciliata—Themeda triandra is an occupant of the lower slopes of koppies and outer edges of bults abutting on the surrounding grassveld, where a more uniform soil-cover is developed.

Koppie bush forms stands on the steep sides of koppies and valleys facing south and south-east, and along the sides of rocky dongas among the koppies. It invariably inhabits deep talus.

Spruit-bank-valley bush lines the banks of spruits and sloots in valleys, and forms scattered clumps on the floors of the latter. It is an occupant of deep alluvial soil.

Acacia bush inhabits deep alluvial soil where the spruits and sloots form flushes near the mouths of the valleys.

Valley grassland occupies relatively moist and deep soil along the sides of watercourses ; in small flushes where Acacia bush is not developed, and areas between the bush clumps in the valleys.

(*c*) The various communities probably represent, each in its own particular habitat, the highest form of vegetation which can develop there to-day, each being essentially in harmony with a relatively stable habitat.

(*d*) The factors concerned in the distribution of the associations are dealt with. Soil is the most important and is shown to be especially significant in the distribution of koppie bush.

(*e*) Two main paths of succession are traced : lithoseric and hydroseric. Of the lithoseric there are two types, moist and dry.

(*f*) Five flowering aspects are described : hibernal, prevernal, vernal, aestival and autumnal.

(*g*) Raunkiaer's spectrum method was applied. Life form spectra of the vegetation of the Area as a whole, and of each association are given, and for comparison, the normal spectrum also. The method was not very successful. The resemblances and relationships of the Area to the Karroo are discussed.

The importance of distinguishing between direct and indirect factors in ecological work is emphasised, and illustrated by the case of koppie bush.

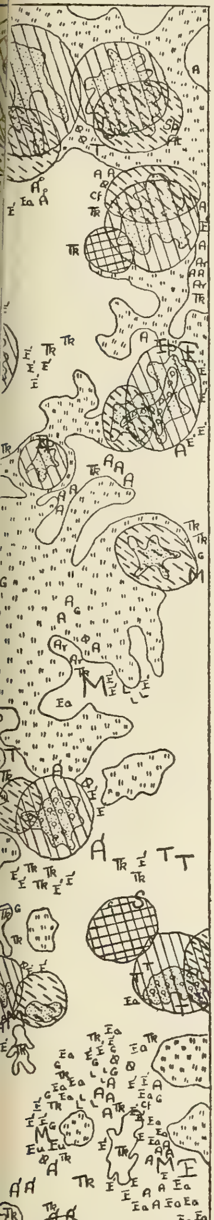
REFERENCES.

1. **Aitken, R. D.** .. The Effect of Slope Exposure on the Climate of a Hill near Maritzburg. S.A. Journ. Sci. XIX, 207-17, Dec. 1922.
2. **Bews, J. W.** .. An Account of the Chief Types of Vegetation in South Africa, with Notes on the Plant Succession. Journ. Ecol. IV, 129-59, 1916.
3. **Bews, J. W.** .. The Grasses and Grasslands of South Africa. Pietermaritzburg, 1918.
4. **Bews, J. W.** .. Plant Forms, and their Evolution in South Africa. London, 1925.
5. **Evans, I. B. Pole** The Plant Geography of South Africa. Union Official Year Book, 3, 48-55, Pretoria 1920.
6. **Evans, I. B. Pole** The Vegetation of South Africa. S.A. and Sci. 192-214, Johannesburg, 1929.
7. **Galpin, E. E.** .. Botanical Survey of the Springbok Flats. Bot. Surv. S.A. 12, 1926.
8. **Phillips, J. F. V.** Some Important Vegetation Communities in the Central Province of Tanganyika Territory. Journ. Ecol. XVIII, 2, 193-234, 1930.
9. **Potts, G.** .. .. The Pepper Tree (*Schinus molle*) as a Cause of Hay Fever in S. Africa. South African Journal of Science XIX, 1922.
10. **Raunkiaer, C.** .. The Life Forms of Plants, and Plant Geography. Oxford, 1934.
11. **Weaver, J. E.**, and **Clements, F. E.** Plant Ecology. New York and London, 1929.

MESEMBRYANTHEMUM SPINOSUM—EUPHORBIA MAURITANICA

Belt Transect showing the size and spacing of the plants.

Scale : 1 inch = 6 feet.



Reference

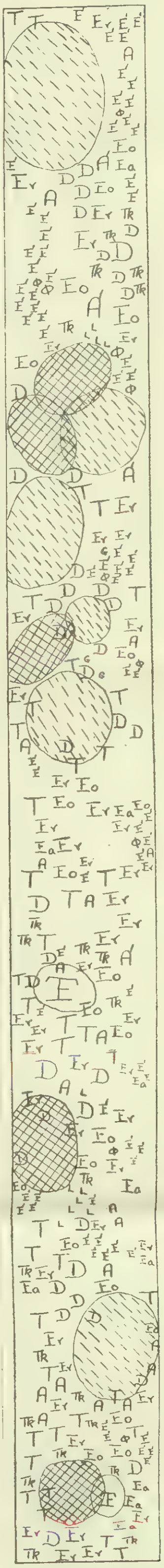
Individuals		Height
▧	Euphorbia mauritanica L	1¼-2½'
▦	Euryops sulcatus Harv	1-1½'
▥	Mesembryanthemum spinosum L	1-2¼'
Groups		
⬚	Kleinia radicans D.C.	1-4½"
⁘	Sarcostemma viminale R. Br.	6-12"
⁙	Close stands of Eragrostis denudata Hack.	3-5½"
A	Aristida congesta Roem & Schult.	6-9"
Á	Aristida Burkei Stapf.	1½-2'
Å	Aristida angustata Stapf.	5-12"
Ar	Aristida barbicollis Trin & Rupr.	6-9"
At	Anthericum paniculatum Moss.	± 18"
Cf	Crassula fruticulosa L	1½-3"
D	Digitaria eriantha Steud.	1½-2¼'
Ea	Eragrostis sp. nr. Atherstonei	6-8"
É	Eragrostis denudata Hack.	3-5½"
Ep	Euphorbia mauritanica L.	14-18"
Eu	Eustachys paspaloides L M.	1¼-2'
F	Eriocephalus spinescens Burch.	6-8"
G	Geigeria passerinoides Harv.	1½-2½"
H	Heliophila suavissima Burch	±18"
L	Lepturella capensis Stapf.	1½-2½"
M	Mesembryanthemum spinosum L.	8-10"
&	Mariscus capensis Schrad.	2-4"
S	Sutera coerulea Hiern.	±7"
Sp	Stapelia flavirostris N.E.Br.	±6½"
T	Themeda triandra Forsk.	1½-2'
Tk	Tragus koelerioides Asch	3-7"

The blank areas represent bare rock surfaces.

Fig. II EURYOPS SULCATUS—EUPHORBIA MAURITANICA

Belt Transect showing the size and spacing of the plants.

Scale : 1 inch = 3 feet.



Reference

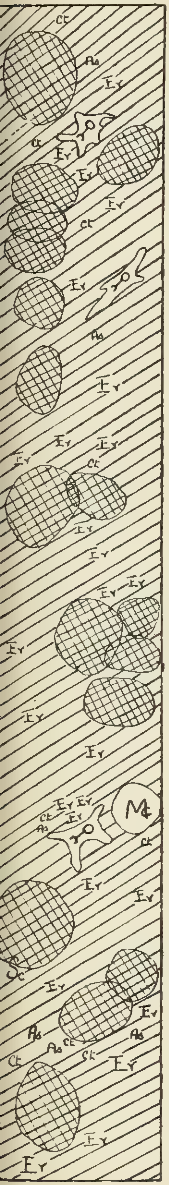
Individuals	Height
▨ Euphorbia mauritanica L.	1¼-2¼'
▩ Euryops sulcatus Harv.	1-2¼'
A : Aristida congesta Roem & Schult.	7-10"
Á : Aristida Burkei Stapf.	1½-2'
D : Digitaria eriantha Steud.	1½-2½'
Ea : Eragrostis sp. nr. Atherstonei.	6-9"
É : Eragrostis denudata Hack.	3½-6"
Eo : Eragrostis obtusa Munro.	6-10"
Er : Eragrostis Lehmanniana Nees.	9-12"
I : Eriocephalus spinescens Burch.	6-8"
L : Leptureila capensis Stapf.	1½-2½"
Φ : Mariscus capensis Schrad.	2-4"
T : Themeda triandra Forsk.	1½-2¼'
Tk : Tragus koelerioides Asch.	3-7"
G : Geigeria passerinoides Harv.	1½-2½"

III.

EURYOPS SULCATUS—THEMEDA TRIANDRA.

Belt Transect showing the size and spacing of the plants.

Scale : 1 inch = 6 feet.



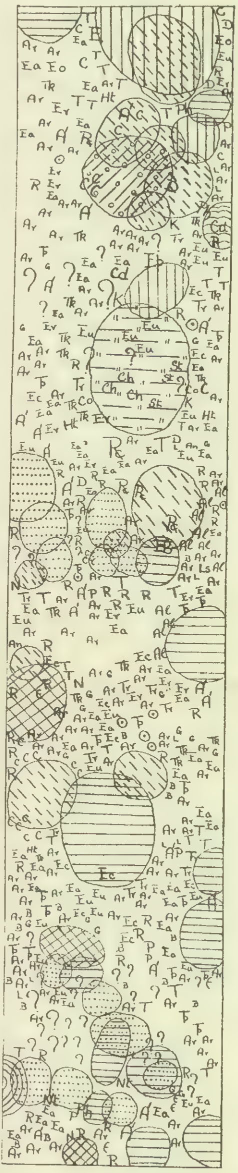
Reference

Individuals		Height
CrossHatch	Euryops sulcatus Harv.	1¼ - 2½'
As	Aster sp.	5 - 7"
Ct	Chrysocoma tenuifolia Berg.	6½ - 9"
♀	Convolvulus ulosepalus Hall.	¾ - 1"
Er	Eragrostis Lehmanniana Nees.	18" - 2'
Mt	Melolobium candicans E & Z.	± 9"
Sc	Scabiosa columbaria L.	8 - 14"
Left Hatch	Close stand of Themeda triandra Forsk.	1½ - 2¾'

Fig. IV

KOPPIE SCRUB.

Belt Transect showing the size and spacing of the plants.
Scale : 1 inch = 6 feet



Reference

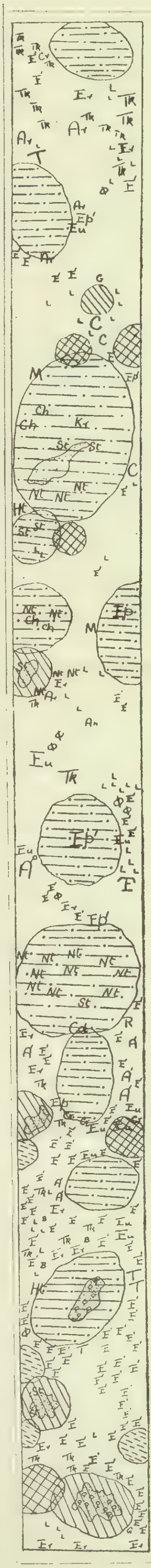
Individuals		Height
░	Euclea ovata Burch.	2½-3½'
◎	Ehretia hottentotica Burch.	±4¼'
▧	Euphorbia mauritanica L	1½-2½'
▤	Euryops multifidus D.C.	2½-3¼'
▦	Euryops sulcatus Harv.	1½-2½'
▥	Olea verrucosa Link.	3-3½'
▭	Rhus Burchelli Sond	±5'
▨	Rhus ciliata Licht.	3½-4'
≋	Royena microphylla Burch.	±1½'
Á	Aristida Burkei Stapf.	1½-2'.
Al	Aloe grandidentata Salm Dyck	12-14"
An	Anacampseros telphiastrum D.C	±3"
Ar	Aristida barbicollis Trin & Rupr.	8-11"
B	Bulbostylis humilis Kunth	1½-2"
C	Cymbopogon plurinodis Stapf.	2-2½'
Cd	Cotyledon decussata Sims.	±8"
Ch	Cheilanthes hirta Sw.	5-8"
Co	Commelina karrooica C.B. Clark.	
Cr	Crassula platyphylla Harv	4-6"
D	Digitaria eriantha Steud	1½-2¼'
I	Euryops sulcatus Harv	±12"
Ea	Eragrostis sp. nr. Atherstonei.	6-9"
EB	Elephantorrhiza Burchellii Benth	±8"
Ec	Eragrostis curvula Nees	1½-2¼'
Ep	Euphorbia mauritanica L	±18"
Er	Eragrostis Lehmanniana Nees	8-12"
Eu	Eustachys paspaloides L M.	1¼-2'
⊙	Eneapogon scoparius Stapf.	9-12"
ϵ	Euryops multifidus D.C.	6-12"
?	Euclea ovata Burch.	9-15"
G	Geigeria passerinoides Harv.	1½-3"
Ht	Heteropogon contortis R & S	1-1¼'
K	Kalanchoe paniculata Harv	2-2¼'
L	Lepturella capensis Stapf	1½-2½"
Ls	Lantana salviaefolia Jacq	±14"
N	Nenax microphylla E & Mey.	6-8"
Nt	Notholaena Eckloniana Kunzl.	6-8"
P	Phyllanthus maderaspatensis L.	6-10"
Ph	Pellaea hastata Pr.	6-11"
R	Rhynchelytrum roseum Stapf & Hubb	12-14"
Rc	Rhus ciliata Licht	1-2½'
St	Sarcostemma viminale R. Br	5-9"
T	Themeda triandra Forsk.	1½-2¼'
Tk	Tragus koelerioides Asch.	3-7"
Tr	Triraphis andropogonoides (Steud) Phill.	2-2½'
Tb	Trichoneura grandiglumis Rend.	7-10"
Eo	Eragrostis obtusa Munro.	6-10"

Fig. IVa.

KOPPIE SCRUB.

Belt Transect through an open stand of Rhigozum obovatum showing the size and spacing of the plants.

Scale : 1 inch=4 feet.



Reference

Individuals

		Height
▨	Euphorbia mauritanica L	1-2'
▩	Euryops multifidus D.C	1½-2½'
⬚	Kleinia radicans D.C.	1-4½"
▧	Mesembryanthemum spinosum L	1-2¼'
▤	Rhigozum obovatum Burch.	3½-9'
░	Sarcostemma viminale R.Br	3-7"

Á	Aristida Burkei Stapf.	1½-2'
Å	Aristida angustata Stapf.	±12"
Ar	Aristida barbicollis Trin. & Rupr.	6-12"
An	Anacampseros telphiastrum D.C.	±3"
B	Bulbostylis humilis Kunth.	1-2¼"
C	Cymbopogon plurinodis Stapf.	2-2½'
Cd	Cotyledon decussata Sims.	±7"
Ch	Cheilanthes hirta Sw.	5-8"
Cr	Crassula platyphylla Harv.	4-6"
É	Eragrostis denudata Hack.	3-5"
Ep	Euphorbia mauritanica L.	±18"
Ep'	Euphorbia caterviflora N.E.Br	8-10"
Er	Eragrostis Lehmanniana Nees	7-9"
Eu	Eustachys paspaloides L.M	1¼-2'
E	Eriocephalus spinescens Burch	±7"
G	Geigeria passerinoides Harv	1½-2½"
Ht	Heteropogon contortus R&S.	1-1¼'
Kr	Kleinia radicans D.C	1-4½"
L	Lepturella capensis Stapf.	1½-2½"
M	Mesembryanthemum spinosum L	5-8"
Ø	Mariscus capensis Schrad	2-4"
R~	Rhynchelytrum roseum Stapf & Hubb	±12"
St	Sarcostemma viminale R. Br.	3-5"
T	Themeda triandra Forsk	1½-2'
Tk	Tragus koelerioides Asch.	3-6"
Nt	Notholaena Eckloniana Kunzl.	6-8"

Fig. V

KOPPIE BUSH.

Belt Transect showing three discontinuous layers of vegetation and the size and spacing of the individual plants.

Scale : 1 inch = 6 feet.

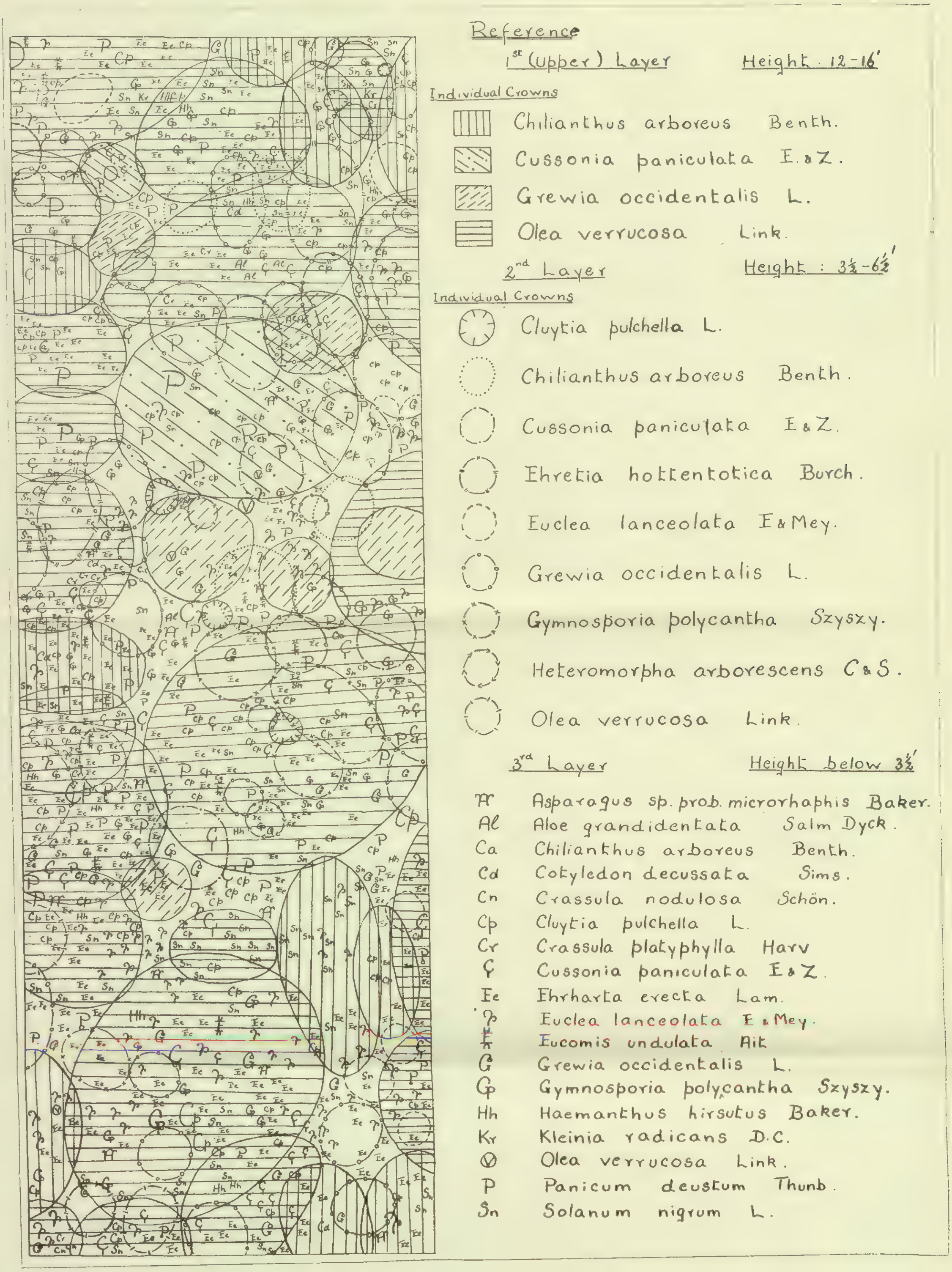

Reference
1st (Upper) Layer Height 12-16'
Individual Crowns
Chilianthus arboreus Benth.
Cussonia paniculata E. & Z.
Grewia occidentalis L.
Olea verrucosa Link.
2nd Layer Height : 3½-6½'
Individual Crowns
Cluytia pulchella L.
Chilianthus arboreus Benth.
Cussonia paniculata E & Z.
Ehretia hottentotica Burch.
Euclea lanceolata E & Mey.
Grewia occidentalis L.
Gymnosporia polycantha Szyszy.
Heteromorpha arborescens C & S.
Olea verrucosa Link.
3rd Layer Height below 3½'
Asparagus sp. prob. microrhaphis Baker.
Al Aloe grandidentata Salm Dyck.
Ca Chilianthus arboreus Benth.
Cd Cotyledon decussata Sims.
Cn Crassula nodulosa Schön.
Cp Cluytia pulchella L.
Cr Crassula platyphylla Harv
Cussonia paniculata E & Z.
Ee Ehrharta erecta Lam.
Euclea lanceolata E & Mey.
Eucomis undulata Ait
G Grewia occidentalis L.
Gp Gymnosporia polycantha Szyszy.
Hh Haemanthus hirsutus Baker.
Kr Kleinia radicans D.C.
Olea verrucosa Link.
P Panicum deustum Thunb.
Sn Solanum nigrum L.

Fig VI.

SPRUIT-BANK-VALLEY-BUSH.

Belt Transect showing four discontinous layers of vegetation and size and spacing of the individual plants.

Scale : 1 inch = 8 feet

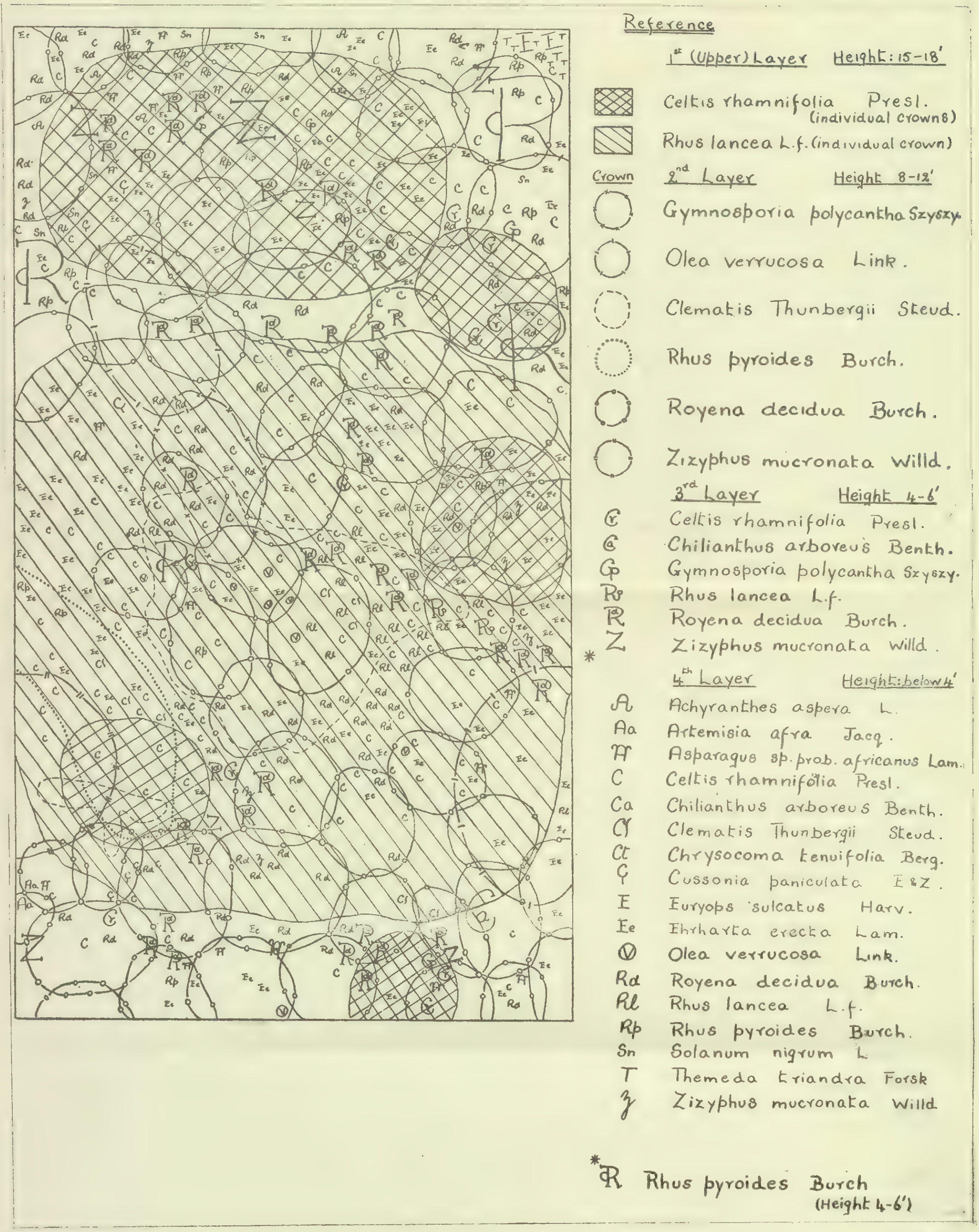
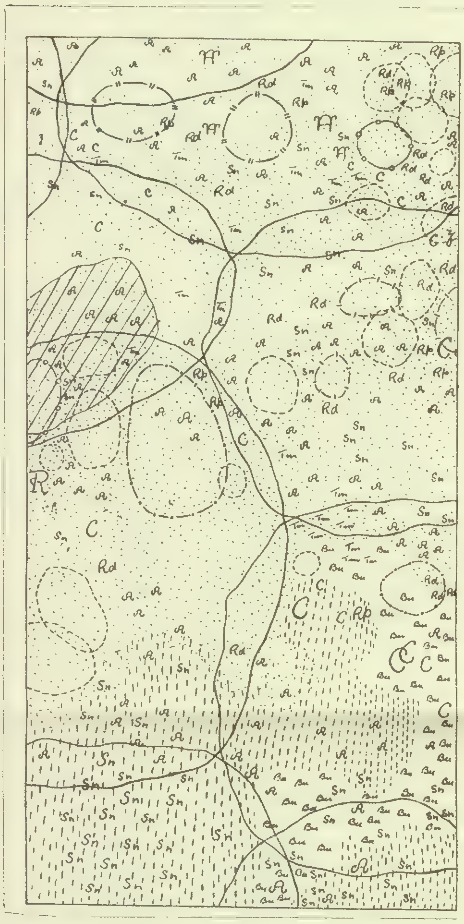

Reference
1st (Upper) Layer Height: 15-18'
▩ Celtis rhamnifolia Presl. (individual crowns)
▧ Rhus lancea L.f. (individual crown)
Crown 2nd Layer Height 8-12'
○ Gymnosporia polycantha Szyszy.
○ Olea verrucosa Link.
○ Clematis Thunbergii Steud.
○ Rhus pyroides Burch.
○ Royena decidua Burch.
○ Zizyphus mucronata Willd.
3rd Layer Height 4-6'
C Celtis rhamnifolia Presl.
C Chilianthus arboreus Benth.
Gp Gymnosporia polycantha Szyszy.
Rl Rhus lancea L.f.
R Royena decidua Burch.
Z Zizyphus mucronata Willd.
4th Layer Height: below 4'
A Achyranthes aspera L.
Aa Artemisia afra Jacq.
A Asparagus sp. prob. africanus Lam.
C Celtis rhamnifolia Presl.
Ca Chilianthus arboreus Benth.
Cl Clematis Thunbergii Steud.
Ct Chrysocoma tenuifolia Berg.
C Cussonia paniculata E & Z.
E Euryops sulcatus Harv.
Ee Ehrharta erecta Lam.
O Olea verrucosa Link.
Rd Royena decidua Burch.
Rl Rhus lancea L.f.
Rp Rhus pyroides Burch.
Sn Solanum nigrum L.
T Themeda triandra Forsk
Z Zizyphus mucronata Willd
*R Rhus pyroides Burch (Height 4-6')

Fig. VII

ACACIA BUSH.

Belt Transect showing the crowns of the dominant trees and the subordinate vegetation.

Scale : 1 inch = 10 feet



Reference

Simple Outline : Crowns of Acacia karroo Hayne. Height: 15-18'

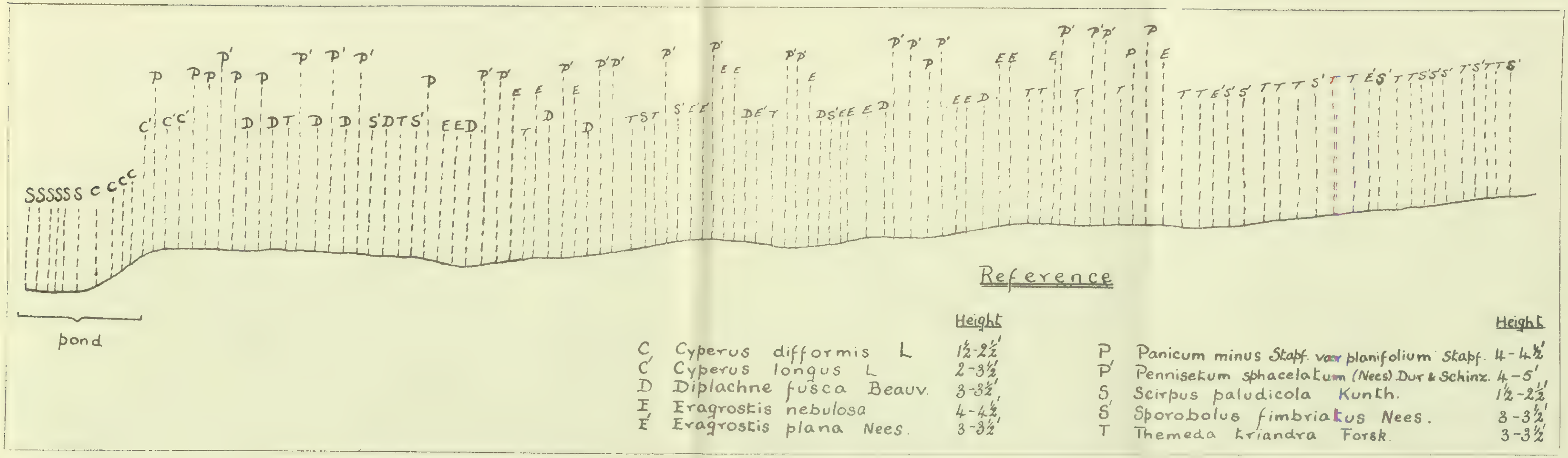
▨	Crown of Royena decidua Burch.	Height: ±12'
○	Acacia karroo Hayne.	Height 4-8'
○	Celtis rhamnifolia Presl.	
○	Rhus lancea L f.	
○	Rhus pyroides Burch.	
○	Zizyphus mucronata Willd.	
R	Rhus pyroides Burch.	
░	Close stand of Bromus unioloides H.B.K.	Height 6-9"
▥	" " " Ihrharta erecta Lam	" ±6"
A	Achyranthes aspera L.	" 9-18"
A	Asparagus sp. prob. africanus Lam	" 2½-3½'
Bu	Bromus unioloides H.B.K.	" 6-9"
C	Celtis rhamnifolia Presl.	" 14"-3½'
Rd	Royena decidua Burch.	" 1-3½'
Rp	Rhus pyroides Burch.	" 1-3½'
Sn	Solanum nigrum L.	" 6"-18"
Tm	Tagetes minuta L.	" 2-3'
Z	Zizyphus mucronata Willd.	" 1½-3'

Fig. VIII

VALLEY GRASSLAND.

Line Transect through a small flush showing zonation.

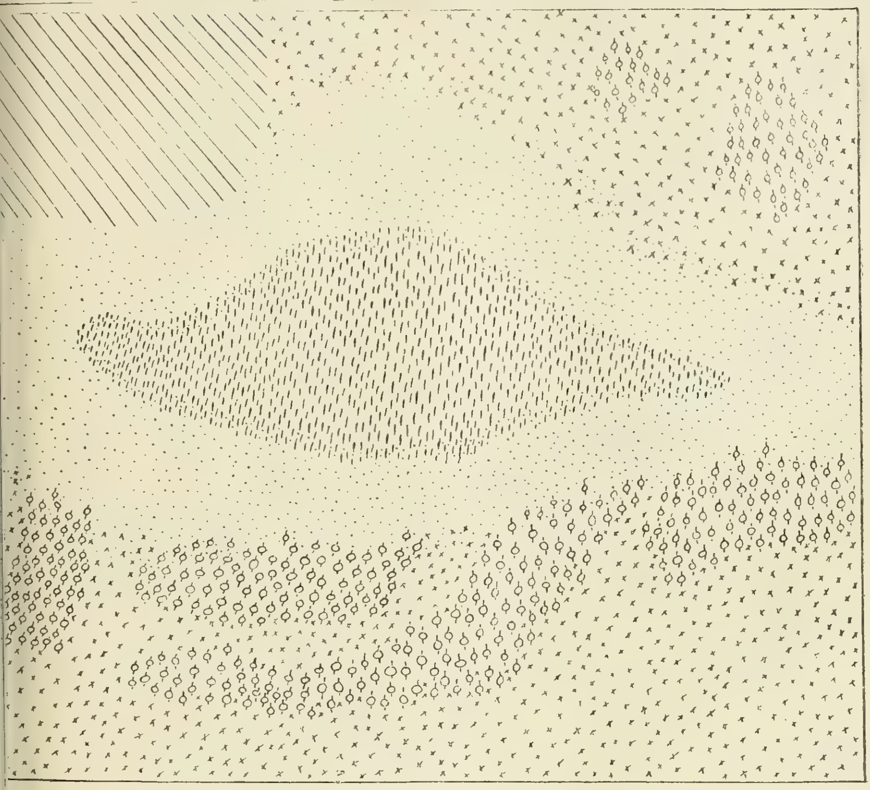
Scale : 1 inch = 3 feet.


pond
Reference
Height
C Cyperus difformis L 1½-2½′
C′ Cyperus longus L 2-3½′
D Diplachne fusca Beauv. 3-3½′
E Eragrostis nebulosa 4-4½′
E′ Eragrostis plana Nees. 3-3½′
Height
P Panicum minus Stapf. var planifolium Stapf. 4-4½′
P′ Pennisetum sphacelatum (Nees) Dur & Schinz. 4-5′
S Scirpus paludicola Kunth. 1½-2½′
S′ Sporobolus fimbriatus Nees. 3-3½′
T Themeda triandra Forsk. 3-3½′

VALLEY GRASSLAND.

Chart of a Small Flush showing Zonation of the Grasses.

Scale: 1 inch = 20 feet.



▥ *Eragrostis nebulosa* with scattered *Panicum minus* Stapf. var. *planifolium* Stapf.

⁙ *Pennisetum sphacelatum* (Nees) Dunn & Schinz with scattered *Panicum minus* Stapf var *planifolium* Sta

◊ *Themeda triandra* Forsk

⁘ *Sporobolus fimbriatus* Nees.

▧ *Acacia* bush.

Fig. X

LINE TRANSECT THROUGH A VALLEY.

Showing the Difference in Vegetation of the Opposite Slopes facing North and South.

Scale: 1 inch = 40 feet.

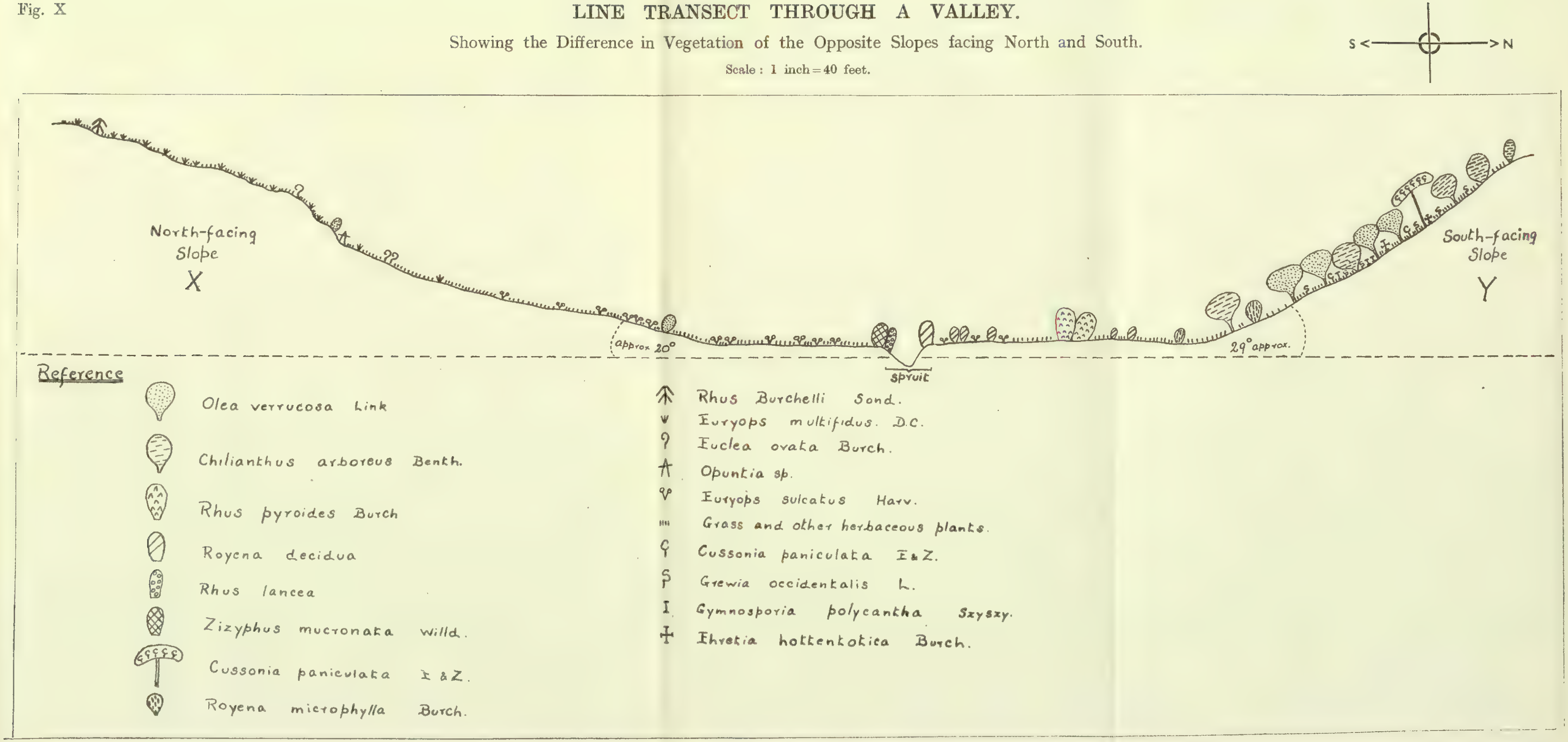


Fig. XI

Comparison of the evaporation, at 8″ above the soil surface, on the two slopes X,Y, Fig. X, January, 1935.

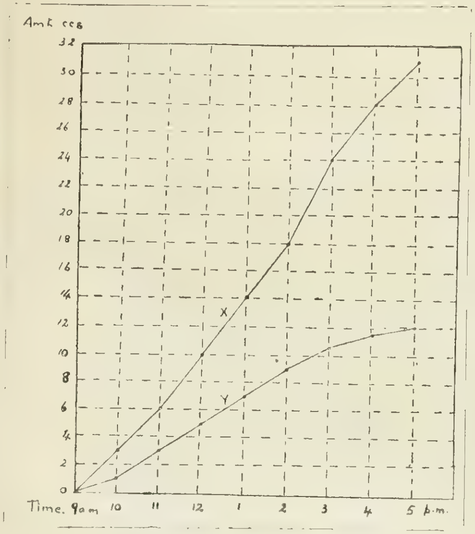


Fig. XII

Comparison of the rates of evaporation, in ccs. per hr., on the two slopes X,Y, Fig. X January, 1935.

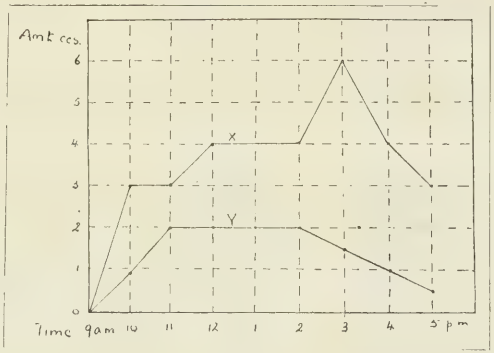


Fig. XIII

Comparison of the ranges of air temperature, at 36″ above the soil surface, on the two slopes X, Y, Fig. X.

January 1935.

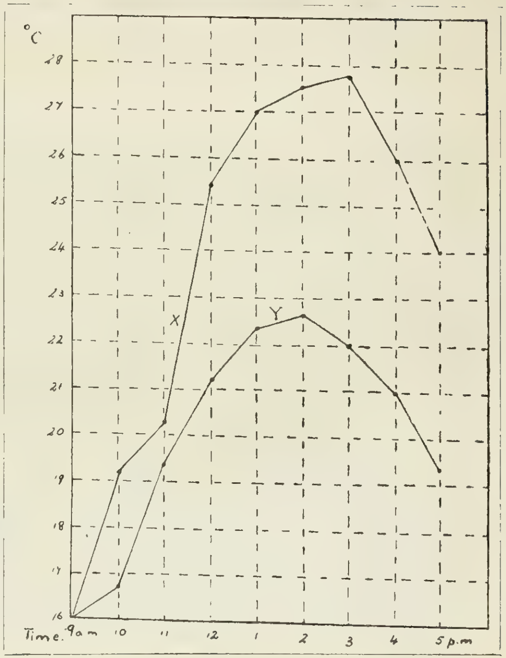


Fig. XIV

Comparison of the ranges of soil temperature at depth of 3″, on the two slopes X, Y, Fig X

January 1935.

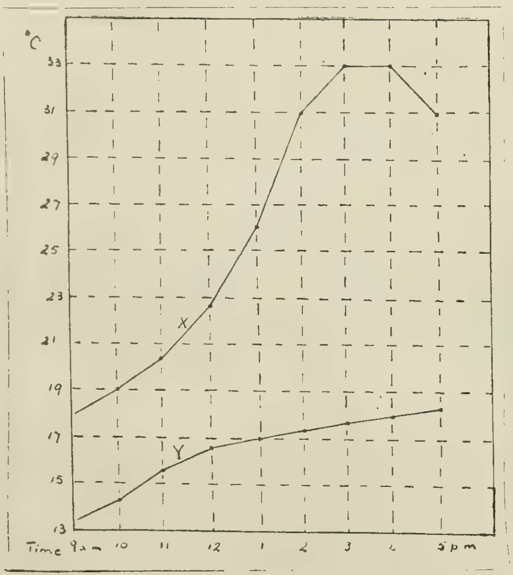


Fig. XV

Comparison of the ranges of relative humidity. at 36″ above the soil surface, on the two slopes X,Y, Fig. X

January, 1935.

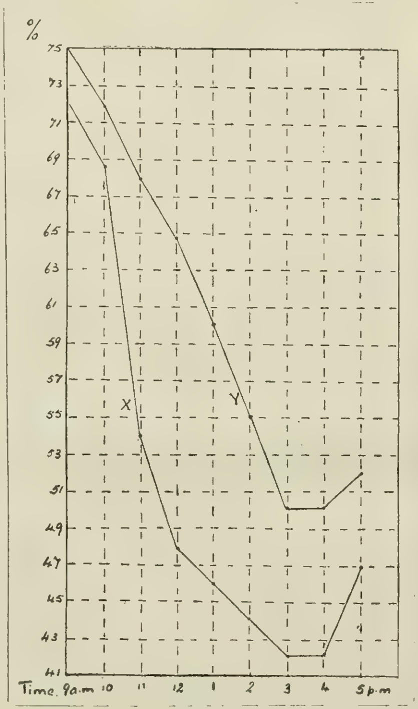
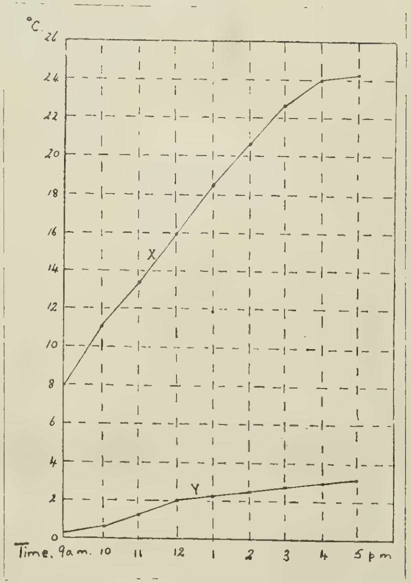


Fig. XVI

Comparison of the ranges of soil temperature, at depth of 3″, on the two slopes X,Y, Fig X.

July, 1935



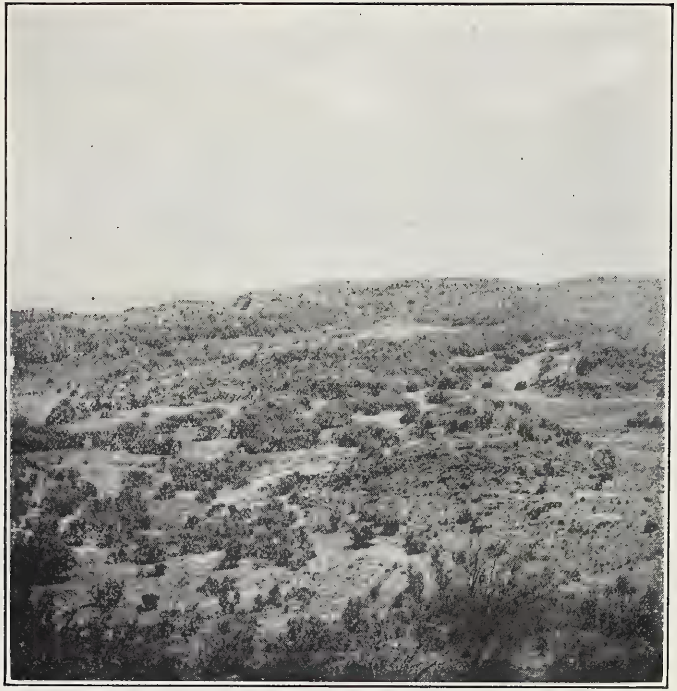


Plate 6A. View of portion of the Area, showing valleys between the koppies. Note the bush clothing the southern faces of the koppies (koppie bush). The bush in the valleys is of a different type (spruit-bank-valley bush). Note the park-like appearance. The small trees in the foreground are *Olea verrucosa* and *Chilianthus arboreus*. The clumps in the valleys are composed of *Rhus lancea*, *R. pyroides*, *Royena decidua*, *Zizyphus mucronata*, *Celtis rhamnifolia*, and *Olea verrucosa*.

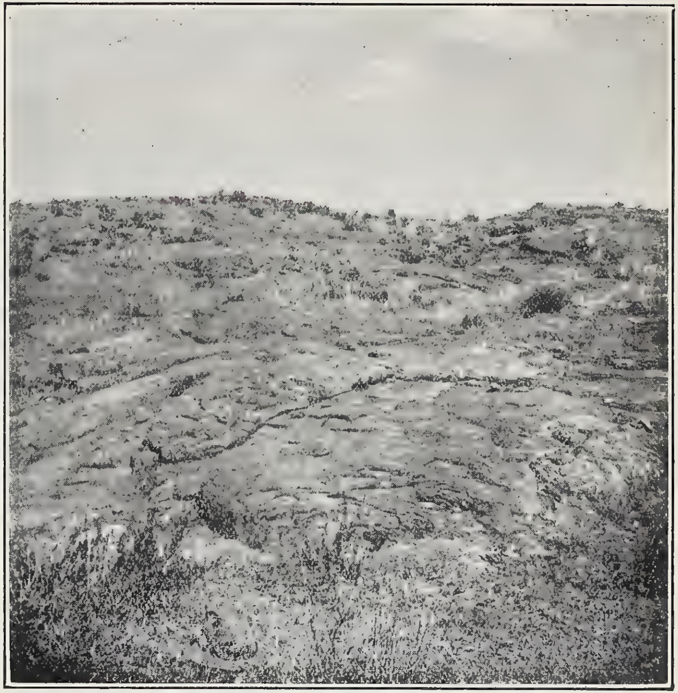


Plate 6B. Heavily eroded koppie slope (facing west). Centre foreground: *Euphorbia mauritanica*. Left foreground: Several individuals of *Euryops multifidus*. Right foreground: Grasses, *Aristida spp.*, *Eragrostis denudata*, *Tragus koelerioides*, and mixed with them, the succulents, *Ruschia unidens*, and *Stomatium mustellinum*. Background: Groups of *Aloe grandidentata*, individuals of *Euryops multifidus*, *Euphorbia mauritanica*, and a mixture of the grasses cited above.

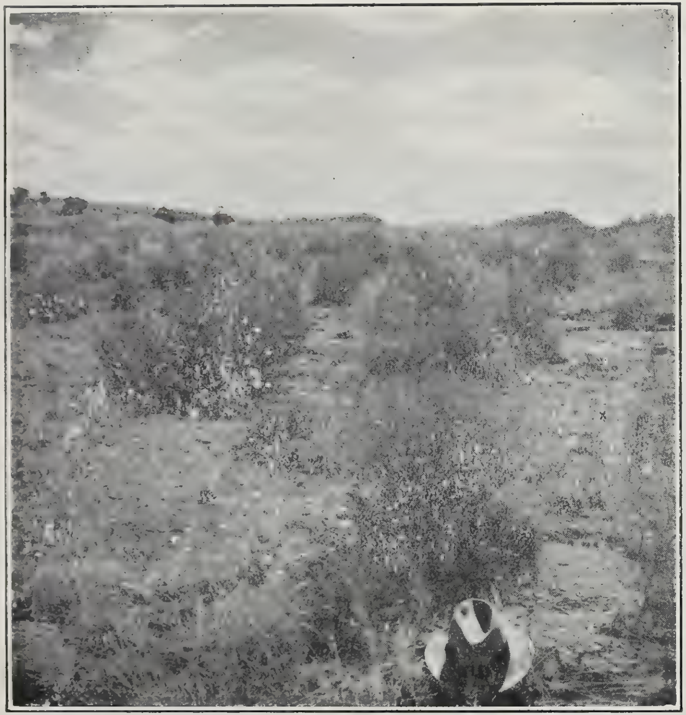


Plate 7a. *Mesembryanthemum spinosum—Euphorbia mauritanica.* The grass in the foreground is mainly *Aristida Burkei.* The stone, left foreground, marks the proximal end of one chain of the belt transect, Fig. I; the chain can be seen stretching back among the plants. Portion of the other chain can be seen to the right stretched between the two crosses marked in ink. Immediately behind the hat is an individual *Euphorbia mauritanica,* and projecting above the latter are a number of inflorescences of *Aristida Burkei.* Further back, centre, is a small individual of *Mesembryanthemum spinosum,* and behind it is seen a group of plants: *M. spinosum, E. mauritanica,* and *Aristida Burkei.* The patches of short grass alongside the left chain are composed chiefly of *Eragrostis denudata* with *Tragus koelerioides.*

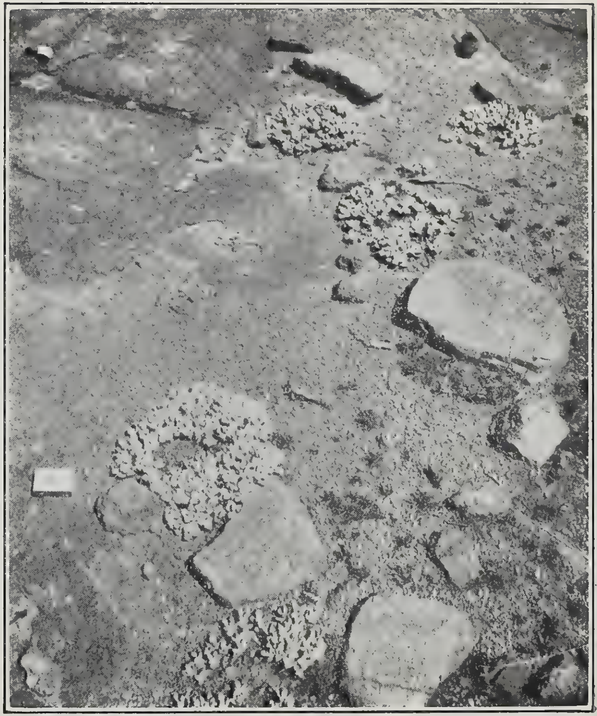


Plate 7b. Stage in the lithoseric succession. In the gravel areas between the rock outcrops are seen several cushions of *Stomatium mustellinum.* To the right are a number of small tufts of *Lepturella capensis.* The match-box affords an idea of size.

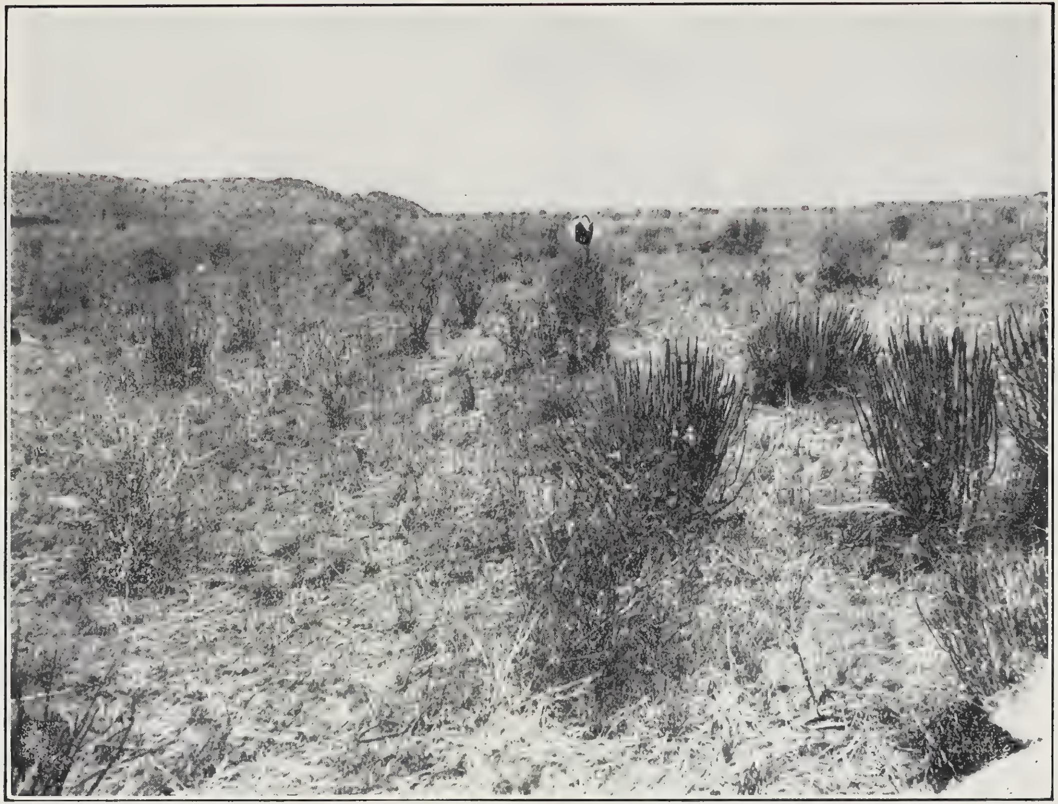


PLATE 8. *Euryops sulcatus—Euphorbia mauritanica.* In the foreground are seen the handles, and portions of the two chains of the belt transect, Fig. II. Between the chains in the foreground is seen a *Euryops sulcatus*, and behind it *Euphorbia mauritanica*. To the right are several plants of *E. mauritanica*, and to the left *Euryops sulcatus*. Note the uniform soil-cover, and the large grass population. The names of the grasses are given with Fig. II. The hat marks the distal end of the transect.

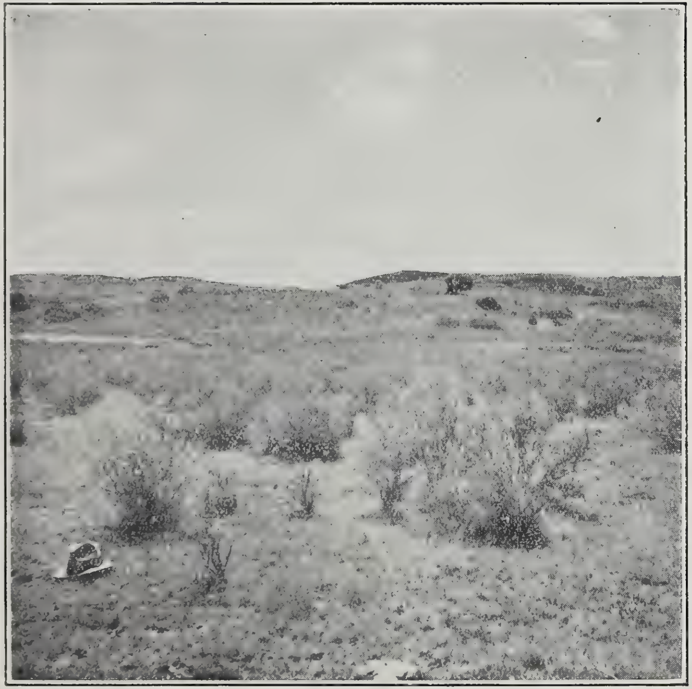


Plate 9a. Well-watered, low-lying area with deep soil in which is a well-developed community of *Euryops sulcatus* in a heavily-cropped Themeda-other-species grassland. Along the base of the bult in the background is faintly seen a grass-lined watercourse. The trees in the background are *Olea verrucosa*, and the scrub on the bult, *E. sulcatus*.

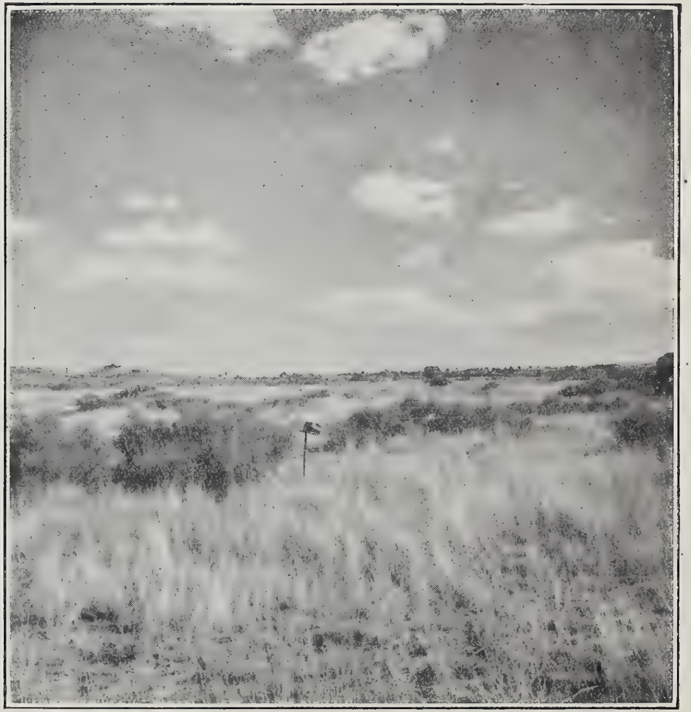


Plate 9b. *Rhus ciliata—Themeda triandra*. The grasses are a mixture of *Themeda triandra*, *Eragrostis spp.*, and *Aristida spp.* The shrub clumps are groups of *Rhus ciliata*. From the hat, placed on a walking-stick, an idea of the heights of the plants is obtained.

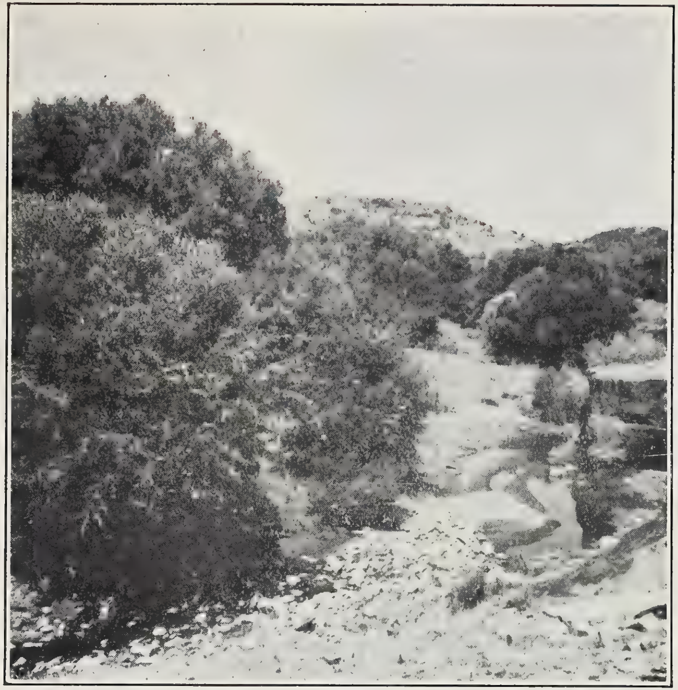


PLATE 10A. Spruit-bank-valley bush lining the banks of a spruit. Left bank: *Olea verrucosa* with *Zizyphus mucronata* projecting from its right margin. The large tree immediately behind is *Rhus lancea*, shown in Fig. VI. To the right of it is a small *Z. mucronata*, behind which is seen *Royena decidua*, and in front, a small individual of *Royena microphylla*. Right bank: Clumps of *Royena decidua*, *Rhus pyroides*, *Zizyphus mucronata*, *Rhus lancea*, and *Celtis rhamnifolia*.

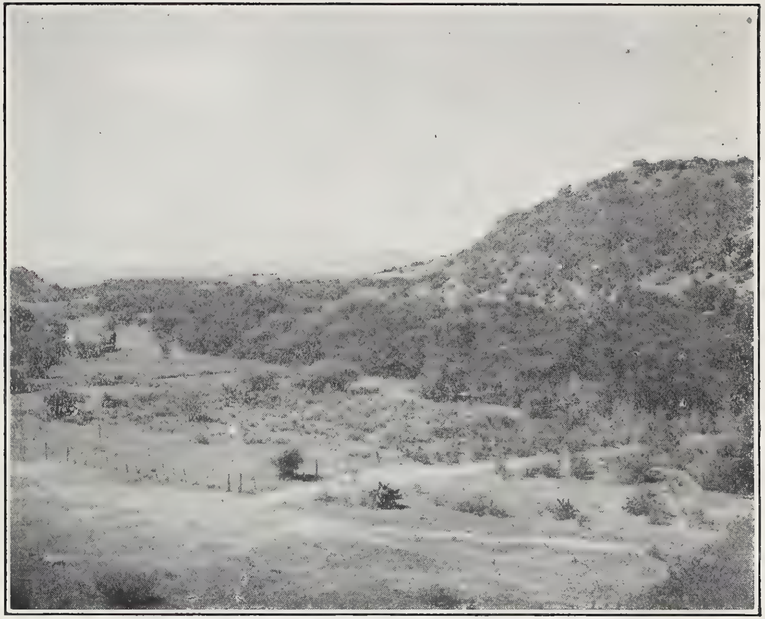


PLATE 10B. Acacia bush. (Tredenham, Map 1.) The scrub in the paddocks is composed of *Rhus ciliata*, *Euryops sulcatus*, young clumps of spruit-bank-valley bush, and *Opuntia spp.* Behind is seen a line of Acacia bush following a flush into the grassveld. To the left, clumps of spruit-bank-valley bush, and in the right background a koppie clothed by koppie bush.

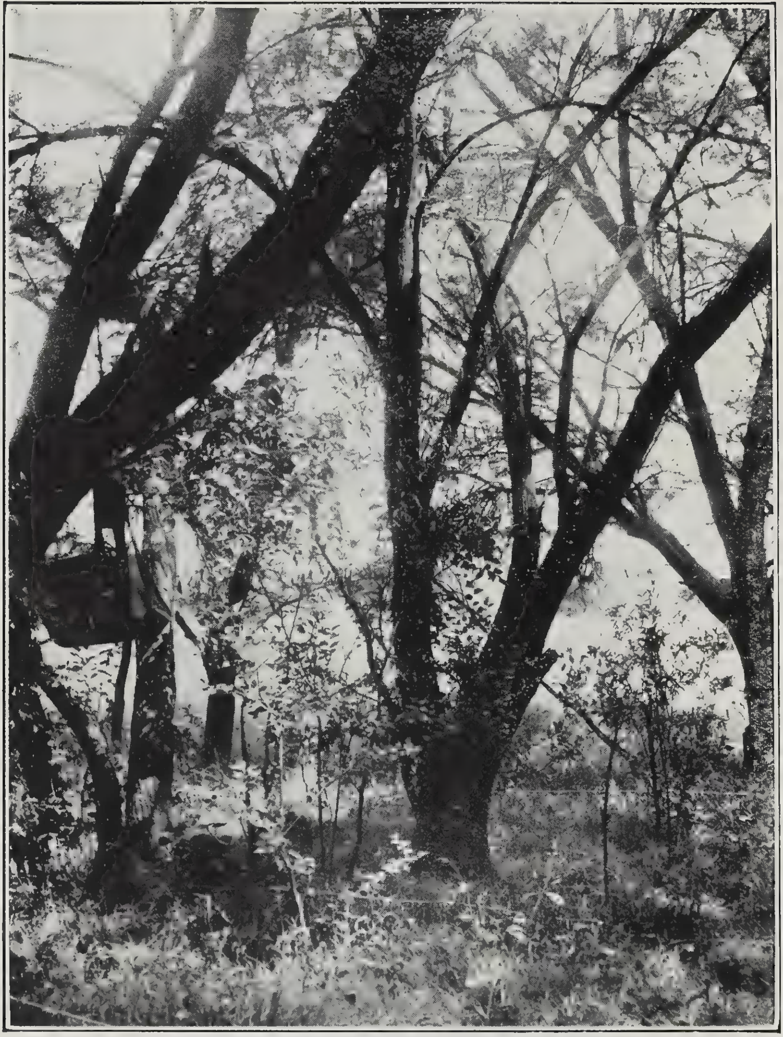


Plate 11. Acacia bush. Inside view of portion of the belt transect, Fig. IX. Portions of three of the transverse lengths of cord of the transect can be seen. The large trees are *Acacia Karroo*. The taller sapling with narrow leaves, centre, is *Rhus lancea*: another individual of it can be seen to the right. The others are *Celtis rhamnifolia*. In the right foreground is an individual *Achyranthes aspera*. The ground vegetation is mainly composed of *Bromus unioloides* and *Ehrharta erecta*.

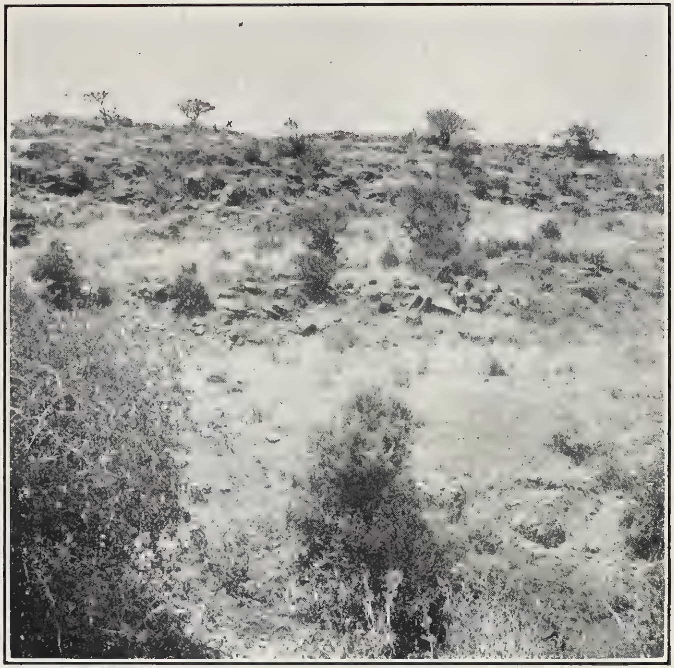


Plate 12a. View of valley slope facing north, shown in Fig. X. The cross on the horizon marks the distal end of the steel tape of the transect. The tape can be faintly seen stretching down the face of the slope. The trees are *Olea verrucosa*, and the shrubs *Euryops multifidus*. The conspicuous grasses are *Aristida spp*. In the left foreground is portion of *Zizyphus mucronata* shown in Fig. X on the bank of the spruit. To the right is a small *Chilianthus arboreus*, and behind it a number of shrubs of *Euryops sulcatus*.

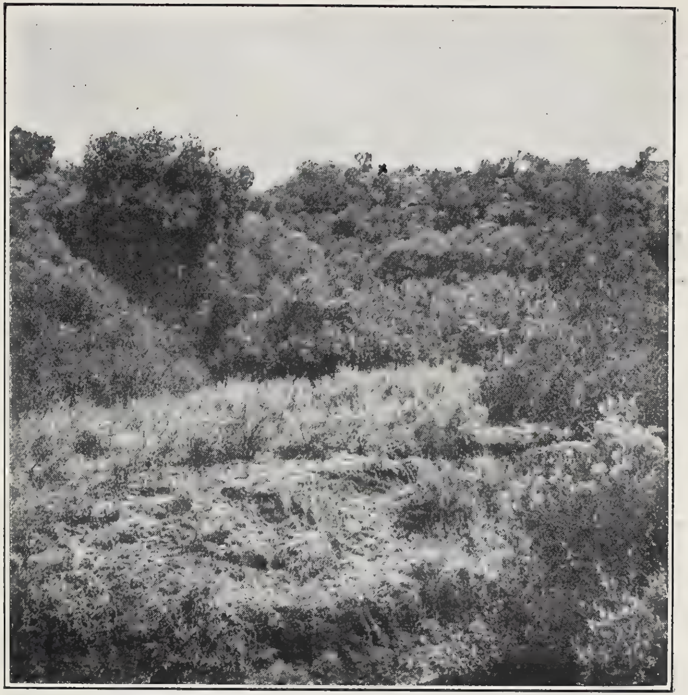


Plate 12b. Bush-covered valley side facing south (see Fig. X). The large tree to the left is *Celtis rhamnifolia*. To the right, marked by a cross, is *Cussonia paniculata*, shown in Fig. X. The shrubs in front are *Euryops sulcatus*. To the right can be seen *Royena decidua*, and portion of *Rhus pyroides*, Fig. X. In the foreground can be seen portion of the bank of the spruit, and right foreground *Chilianthus arboreus* in flower.

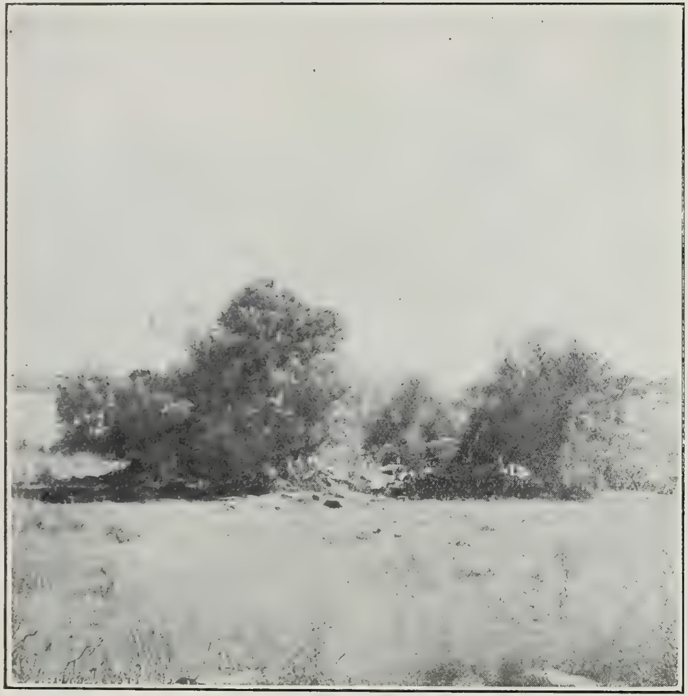


Plate 13a. Ring of bush developed in the tumbled-down walls of an old military sconce on a treeless bult (Bayswater). The bush-ring is composed of a number of *Chilianthus arboreus*. The grasses are *Eragrostis spp.*, *Aristida spp.*, and *Themeda triandra*. Portions of *Euryops sulcatus* can be seen in the immediate foreground.

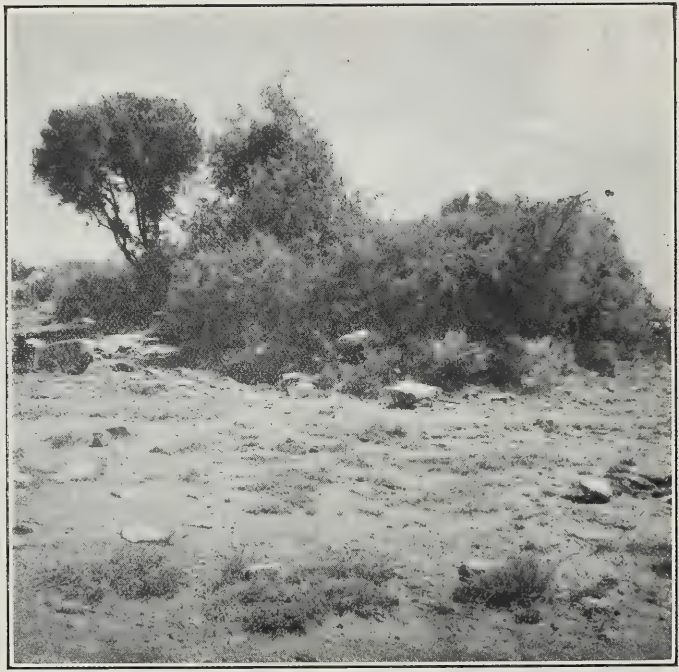
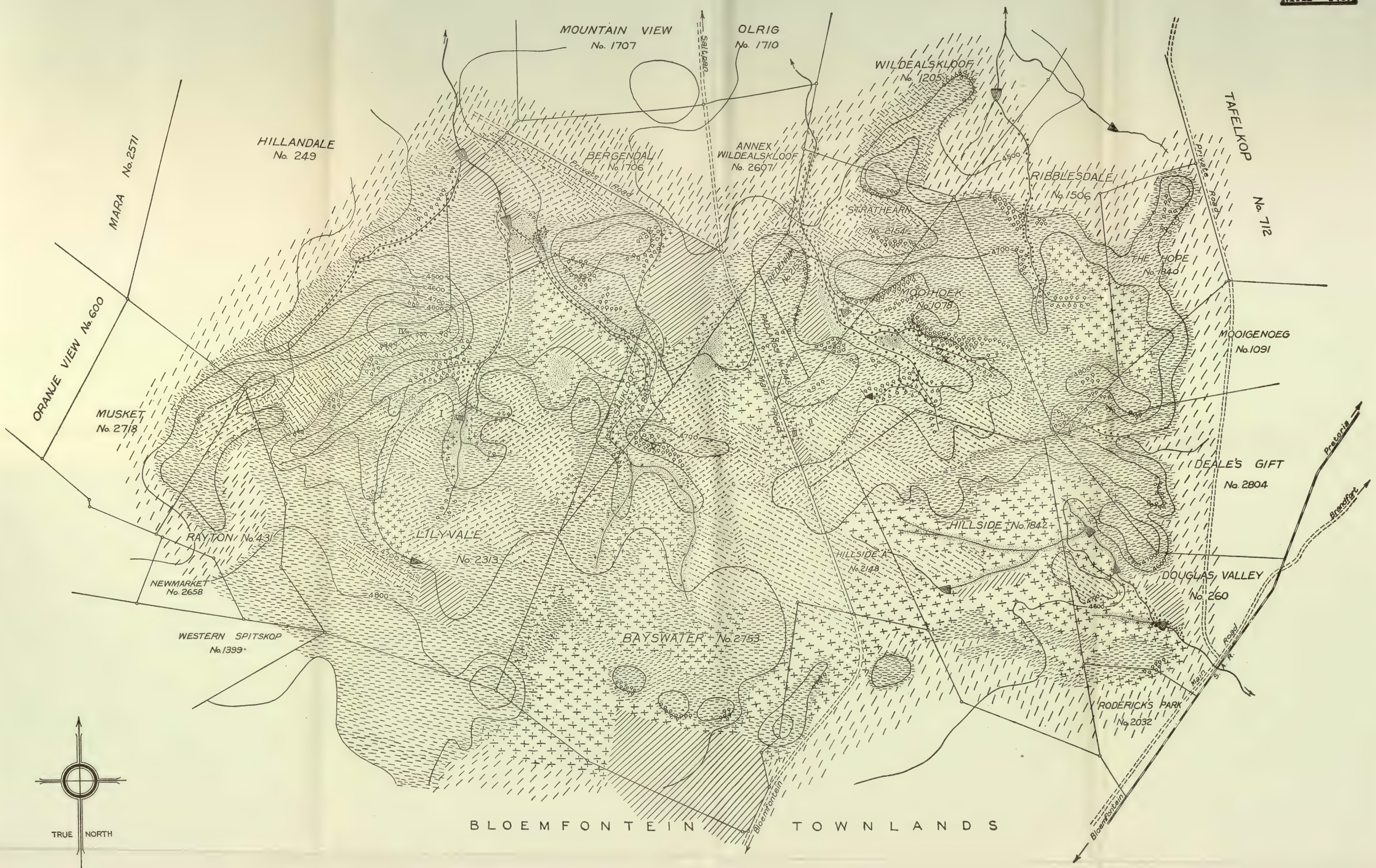


Plate 13b. Clump of bush on a low bult (Hillside) in a rocky rubble, believed to have been caused by blasting. A number of irregular boulders are seen strewn about the foot of the clump. The tree on the left is *Olea verrucosa*, and to the right of it is another individual of the same species being overwhelmed by *Zizyphus mucronata*. The shorter growth is made up of a tangle of *Zizyphus mucronata* and *Gymnosporia polyacantha*.

MAP No.1



REFERENCE

SCRUB

Mesembryanthemum spinosum - Euphorbia mauritanica ▨
Euryops sulcatus - Euphorbia mauritanica ▨
Euryops sulcatus -- Themeda triandra ▨
Koppie scrub ▨
Rhus ciliata - Themeda triandra ▨

THE DISTRIBUTION OF THE ASSOCIATIONS

Approximate Scale. 1 Inch = 560 Yards

▨ Disturbed Areas.

REFERENCE

BUSH

▨ Koppie bush.
▨ Spruit - bank - valley bush.
▨ Acacia bush.

GRASSLAND

▨ Valley grassland.
▨ Themeda grassland.